Operating Instructions

Diesel engine
12 V 2000 M94
16 V 2000 M94

MS150061/03E

Power. Passion. Partnership.

Printed in Germany

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This handbook is provided for use by maintenance and operating personnel in order to avoid malfunctions or damage during operation.

Subject to alterations and amendments.

Commissioning Note

Table of Contents

1 Safety

1.1 General conditions 7
1.2 Personnel and organizational requirements 8
1.3 Transportation 9
1.4 Safety regulations for startup and operation 12
1.5 Safety regulations for maintenance and repair work 13
1.6 Auxiliary materials, fire prevention and environmental protection 16
1.7 Conventions for safety instructions in the text 18

2 General Information

2.1 Engine side and cylinder designations 19
2.2 Product description 20
2.3 Engine - Overview 26
2.4 Sensors, actuators and injectors – Overview 28

3 Technical Data

3.1 12V 2000 M94 engine data 33
3.2 16V 2000 M94 engine data 36
3.3 Firing order 39
3.4 Engine – Main dimensions 40

4 Operation

4.1 Putting the engine into operation after extended out-of-service periods (>3 months) 41
4.2 Engine – Putting into operation after scheduled out-of-service-period 42
4.3 Tasks after extended out-of-service periods (>3 weeks) 43
4.4 Checks prior to start-up 44
4.5 Fuel treatment system – Putting into operation 45
4.6 Operational checks 47
4.7 Fuel treatment system – Switching on 48
4.8 Starting the engine 49
4.9 Stopping the engine 50
4.10 Emergency stop 51
4.11 After stopping the engine 52
4.12 Fuel treatment system – Shutdown 53
4.13 Plant – Cleaning 54

5 Maintenance

5.1 Maintenance task reference table [QL1] 55

6 Troubleshooting

6.1 Fuel treatment system – Troubleshooting 56
6.2 Troubleshooting 57

7 Task Description

7.1 SOLAS 60
7.1.1 SOLAS shielding as per MTN 5233 – Installation 60
7.1.2 SOLAS- Abschirmung anbringen 61
7.1.3 Installation locations for SOLAS shielding 62

7.2 Engine 67
7.2.1 Engine – Barring manually 67
7.2.2 Engine – Barring with starting equipment 68

7.3 Cylinder Liner 69
7.3.1 Cylinder liner – Endoscopic examination 69
7.3.2 Cylinder liner – Instructions and comments on endoscopic and visual examination 71

7.4 Crankcase Breather 73
7.4.1 Crankcase breather – Cleaning oil pre-separator element 73
7.4.2 Kurbelgehäuseentlüftung – Ölabscheidereinsatz ersetzen, Membrane prüfen und ersetzen 74

7.5 Valve Drive 76
7.5.1 Valve clearance – Check and adjustment 76
7.5.2 Cylinder-head cover – Removal and installation 79

7.6 Injection Valve / Injector 80
7.6.1 Injector – Replacement 80
7.6.2 Injector – Removal and installation 81

7.7 Fuel System 83
7.7.1 Fuel system – Venting 83

7.8 Fuel Filter 84
7.8.1 Fuel filter – Replacement 84
7.8.2 Fuel prefilter – Differential pressure check and adjustment of gauge 86
7.8.3 Fuel prefilter – Draining 87

DCL-ID: 0000010704 - 003

7.8.4 Kraftstoffvorfilter spülen 88
7.8.5 Fuel prefilter – Filter element replacement 90

7.9 Charge-Air Cooling 92
7.9.1 Intercooler – Checking condensate drain line for coolant discharge and obstruction 92

7.10 Air Filter 93
7.10.1 Luftfilter ersetzen 93
7.10.2 Air filter – Removal and installation 94

7.11 Air Intake 95
7.11.1 Contamination indicator – Signal ring position check 95

7.12 Starting Equipment 96
7.12.1 Starter – Condition check 96

7.13 Lube Oil System, Lube Oil Circuit 97
7.13.1 Engine oil – Level check 97
7.13.2 Engine oil – Change 98

7.14 Oil Filtration / Cooling 99
7.14.1 Engine oil filter – Replacement 99
7.14.2 Ölzentrifuge reinigen und Einlegemanschette ersetzen 101

7.15 Coolant Circuit, General, High-Temperature Circuit 104
7.15.1 Drain and venting points 104
7.15.2 Engine coolant – Level check 110
7.15.3 Motorkühlmittel wechseln 111
7.15.4 Engine coolant – Draining 112
7.15.5 Engine coolant – Filling 113
7.15.6 HT coolant pump — Relief bore check 114
7.15.7 Engine coolant – Sample extraction and analysis 115
7.15.8 Coolant filter – Replacement 116

7.16 Raw Water Pump with Connections 117
7.16.1 Raw water pump – Relief bore check 117

7.17 Belt Drive 118
7.17.1 Drive belt – Condition check 118

7.18 Battery-Charging Generator 119
7.18.1 Battery-charging generator drive – Drive belt replacement 119

7.19 Fuel Supply System 120
7.19.1 Water drain valve – Check 120
7.19.2 Differential pressure gauge – Check 121
7.19.3 Water level probe (3-in-1 rod electrode) – Check 122
7.19.4 Pump capacity – Check 123
7.19.5 Coalescer filter element – Replacement 124

7.20 Wiring (General) for Engine/Gearbox/Unit 126
7.20.1 Engine wiring – Check 126

7.21 Accessories for (Electronic) Engine Governor / Control System 127
7.21.1 Engine governor and connectors – Cleaning 127
7.21.2 Engine governor – Checking plug-in connections 128
7.21.3 EMU – Checking plug-in connections 129
7.21.4 Engine governor – Carry out self-test 130
7.21.5 EMU and connectors – Cleaning 131
7.21.6 ECU 7 engine governor – Removal and installation 132
7.21.7 Engine monitoring unit – Removal and installation 133

8 Appendix A

8.1 Abbreviations 134
8.2 MTU contacts/service partners 136

9 Appendix B

9.1 Special Tools 137
9.2 Index 140

DCL-ID: 000001070 4 - 003

1 Safety

1.1 General conditions

General

In addition to the instructions in this publication, the applicable country-specific legislation and other compulsory regulations regarding accident prevention and environmental protection must be observed. This state-of-the-art engine has been designed to meet all applicable laws and regulations. The engine may nevertheless present a risk of injury or damage in the following cases:

- Incorrect use
- Operation, maintenance and repair by unqualified personnel
- Modifications or conversions
- Noncompliance with the Safety Instructions

Correct use

The engine is intended solely for use in accordance with contractual agreements and the purpose envisaged for it on delivery. Any other use is considered improper use. The engine manufacturer accepts no liability whatsoever for resultant damage or injury in such case. The responsibility is borne by the user alone.

Correct use also includes observation of and compliance with the maintenance specifications.

Modifications or conversions

Unauthorized modifications to the engine represent a safety risk.

MTU will accept no liability or warranty claims for any damage caused by unauthorized modifications or conversions.

Spare parts

Only genuine MTU spare parts must be used to replace components or assemblies. MTU accepts no liability whatsoever for damage or injury resulting from the use of other spare parts and the warranty shall be voided in such case.

Reworking components

Repair or engine overhaul must be carried out in workshops authorized by MTU.

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1.2 Personnel and organizational requirements

Personnel requirements

Work on the engine must only be carried out by appropriately qualified and instructed personnel.

Observe the minimum legal age.

Responsibilities of the operating, maintenance and repair personnel must be specified by the operating company.

Organizational measures

This publication must be issued to all personnel involved in operation, maintenance, repair or transportation.

Keep it handy in the vicinity of the engine such that it is accessible to operating, maintenance, repair and transport personnel at all times.

Use the manual as a basis for instructing personnel on engine operation and repair. In particular, personnel must have read and understood the safety-relevant instructions.

This is especially important for personnel who work on the engine only on an occasional basis. These persons shall receive repeated instruction.

Use the Spare Parts Catalog to identify spare parts during maintenance and repair work.

Working clothes and protective equipment

Wear proper protective clothing for all work.

Depending on the kind of work, use the necessary personal protective equipment.

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1.3 Transportation

Transport without flange-mounted gearbox

Illustration is essentially valid for 8V 2000 M engines

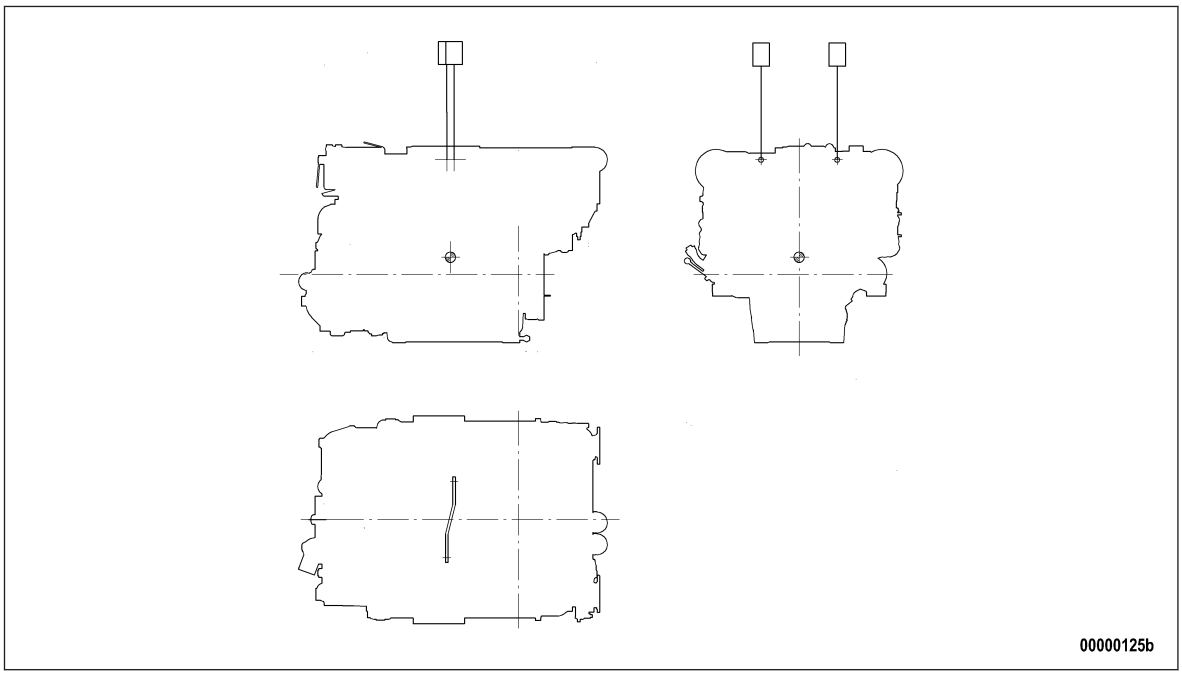
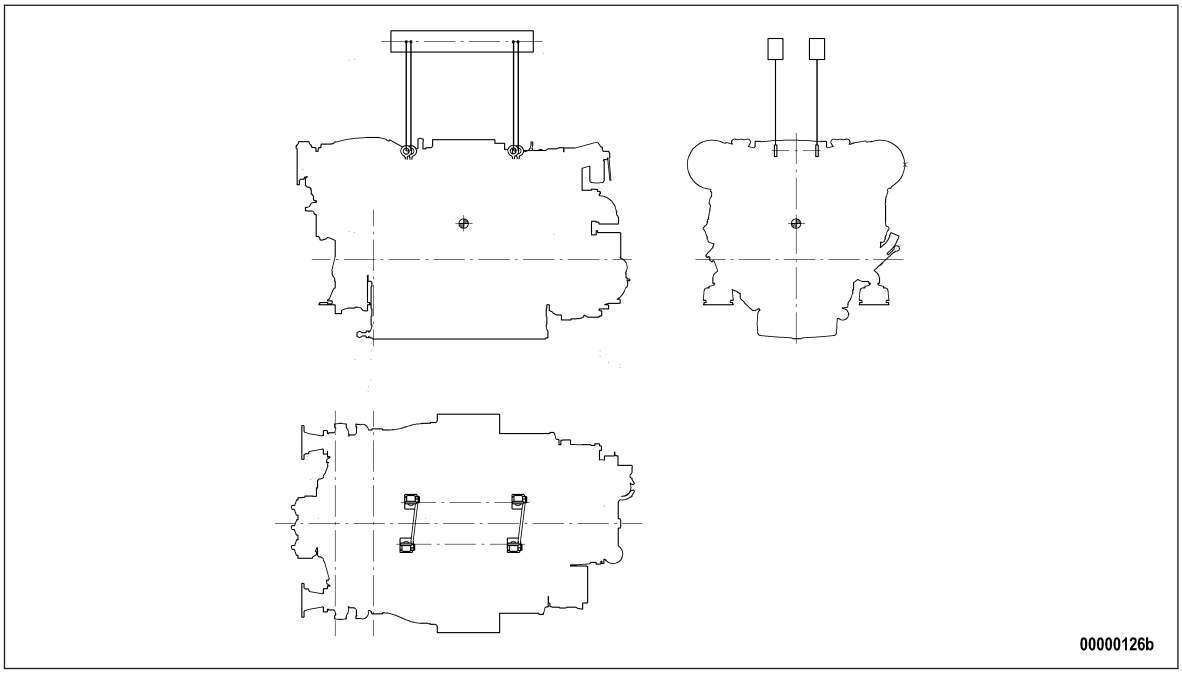


Illustration is essentially valid for 12/16V 2000 M engines



Transport with flange-mounted gearbox

Illustration is essentially valid for 8V 2000 M engines

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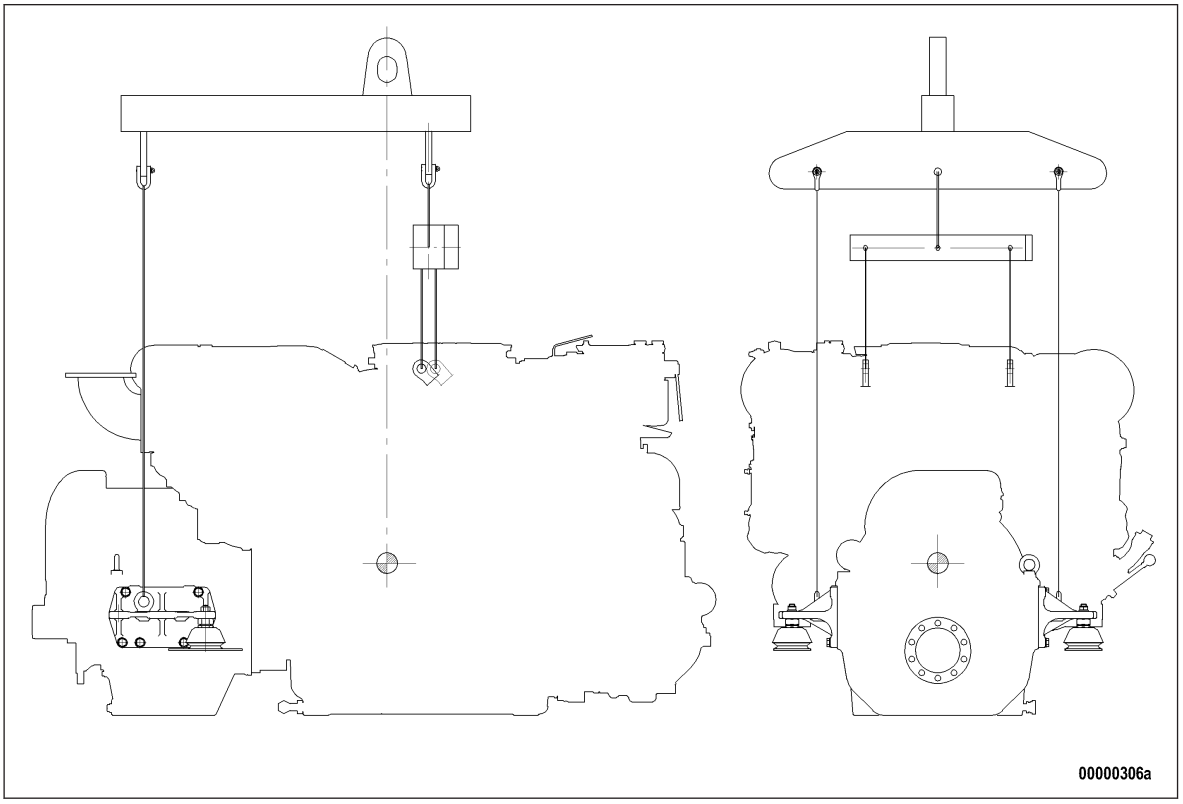
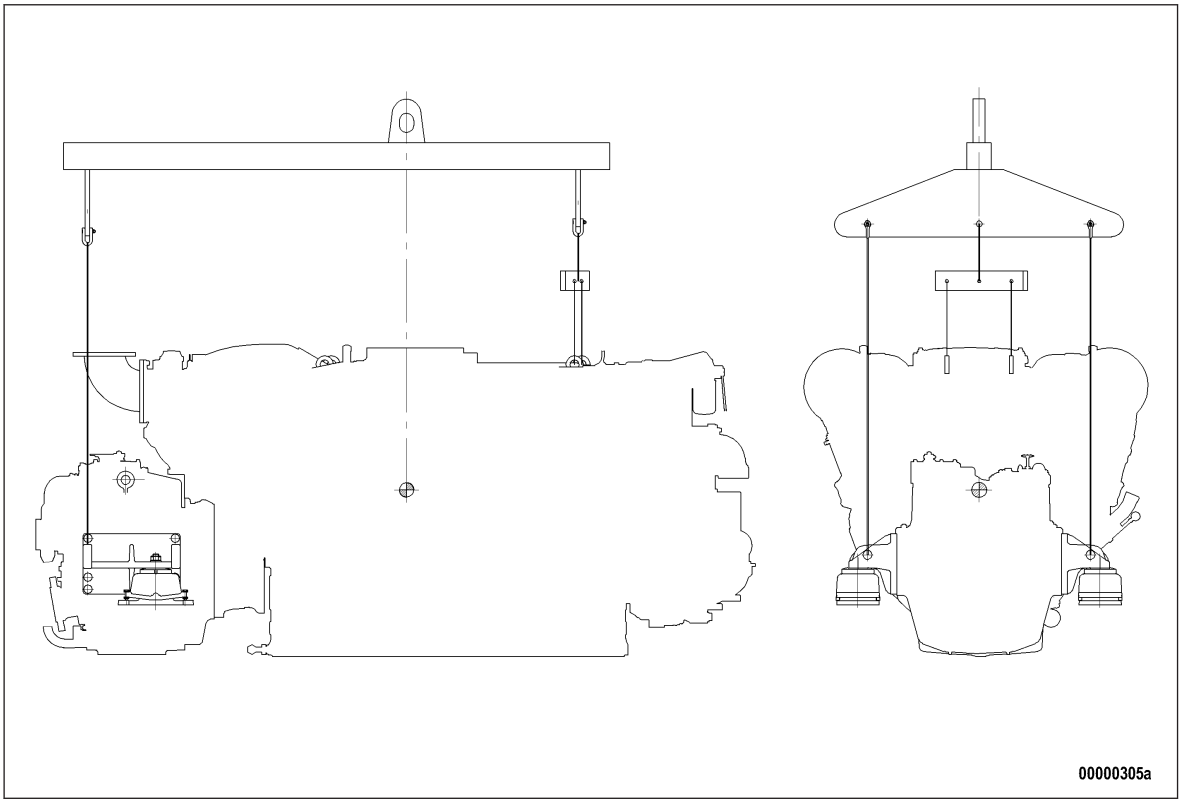


Illustration is essentially valid for 12/16V 2000 M engines



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Only use the lifting eyes provided to lift the engine.

The eyebolts mounted at the driving end and on the gearbox must not be used for transporting plants with flange-mounted gearboxes.

Only use transport and lifting devices approved by MTU.

Take the engine's center of gravity into account.

The engine must only be transported in installation position, max. permissible diagonal pull 10°.

If the engine is supplied with special aluminum foil packing, lift the engine at the lifting eyes of the bearing pedestal or use a means of transportation which is appropriate for the given weight (forklift truck).

Install the crankshaft locking device and the locking screws for the engine mounts prior to engine transportation.

Secure the engine against tilting during transport. In particular when going down inclines or ramps, the engine must be secured against moving and tilting.

Setting the engine down after transport

Only set down engine on a firm, level surface.

Make sure that the consistency and load-bearing capacity of the ground or support surface is adequate.

Never set an engine down on the oil pan unless expressively authorized to do so by MTU on a case-to-case basis.

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1.4 Safety regulations for startup and operation

Safety requirements for initial operation

Prior to initial operation of the unit, install the assembly or unit according to the specifications and check the installation according to the MTU specifications.

Before putting the device or plant into operation, always ensure:
- that all maintenance and repair work is completed,
- that all loose parts have been removed from rotating machine components,
- that nobody is in the danger area of moving machine parts.

Immediately after putting the device or plant into operation, make sure that all control and display instruments as well as the signaling and alarm systems work properly.

Safety requirements for operators

The procedures for cases of emergency must be practiced regularly.

The operator must be familiar with the control and display elements.

The operator must be familiar with the consequences of any operations performed.

During operation, the display instruments and monitoring units must be permanently observed with regard to present operating status, violation of limit values and warning or alarm messages.

The following steps must be taken if a malfunction of the system is recognized or reported by the system:
- inform supervisor(s) in charge,
- analyze the message,
- if required, carry out emergency operations e.g. emergency engine stop.

Engine operation

The following conditions must be fulfilled before starting the engine:
- Wear ear protection.
- Ensure that the engine room is well ventilated.
- Do not inhale engine exhaust gases.
- Ensure that the exhaust system is free of leaks and that the gases are discharged to atmosphere.
- Mop up any leaked or spilt fluids and lubricants immediately or soak up with a suitable binding agent.
- Protect battery terminals, battery-charger terminals and cables against accidental contact.
- When the engine is running, never release coolant, oil, fuel, compressed-air or hydraulic lines.

Operation of electrical equipment

When electrical equipment is in operation, certain components of these appliances are electrically live.

Observe the safety instructions for these devices.

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1.5 Safety regulations for maintenance and repair work

Safety regulations for maintenance and repair work

Have maintenance and repair work carried out by qualified and authorized personnel only.

Allow the engine to cool down before starting maintenance work (risk of explosion of oil vapors).

Before starting work, relieve pressure in systems and compressed-air lines which are to be opened.

Take special care when removing ventilation or plug screws from the engine. Cover the screw or plug with a rag to prevent fluids escaping under pressure.

Take special care when draining hot fluids ⇒ Risk of injury.

When changing the engine oil or working on the fuel system, ensure that the engine room is adequately ventilated.

Allow the engine / system to cool down before starting to work.

Observe the maintenance and repair instructions.

Never carry out maintenance and repair work with the engine running unless expressly instructed to do so.

Secure the engine against accidental starting.

Disconnect the battery when electrical starters are fitted.

Close the main valve on the compressed-air system and vent the compressed-air line when pneumatic starters are fitted.

Disconnect the control equipment from the assembly or system.

Use only proper, calibrated tools. Observe the specified tightening torques during assembly/disassembly.

Carry out work only on assembles and/or units which are properly secured.

Never use lines for climbing.

Keep fuel injection lines and connections clean.

Always seal connections with caps or covers if a line is removed or opened.

Take care not to damage lines, in particular fuel lines, during maintenance and repair work.

Ensure that all retainers and dampers are installed correctly.

Ensure that all fuel injection and pressurized oil lines are installed with enough clearance to prevent contact with other components. Do not place fuel or oil lines near hot components.

Do not touch elastomeric seals if they have carbonized or resinous appearance unless hands are properly protected.

Note cooling time for components which are heated for installation or removal ⇒ Risk of burning.

When working high on the engine, always use suitable ladders and work platforms. Make sure components are placed on stable surfaces.

Observe special cleanness when conducting maintenance and repair work on the assembly or system. After completion of maintenance and repair work, make sure that no loose objects are in/on the assembly or system.

Before barring the engine, make sure that nobody is standing in the danger zone. Check that all guards have been reinstalled and that all tools and loose parts have been removed after working on the engine.

The following additional instructions apply to starters with beryllium copper pinion:

- Breathing protection of filter class P2 must be applied during maintenance work to avoid health hazards caused by the beryllium-containing pinion. Do not blow out the interior of the flywheel housing or the starter with compressed air. Clean the flywheel housing inside with a class H dust extraction device as an additional measure.

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Welding work

Never carry out welding work on the assembly, system, or engine-mounted units. Cover the engine when welding in its vicinity.

Do not use the assembly or system as ground terminal.

Do not route the welding lead over or near the wiring harnesses of MTU systems. The welding current may otherwise induce an interference voltage in the wiring harnesses which could conceivably damage the electrical system.

Remove parts (e.g. exhaust pipes) which are to be welded from the engine beforehand.

Hydraulic installation and removal

Check the function and safe operating condition of tools and fixtures to be used. Use only the specified devices for hydraulic removal/installation procedures.

Observe the max. permissible push-on pressure specified for the equipment.

Do not attempt to bend or apply force to lines.

Before starting work, pay attention to the following:
- Vent the hydraulic installation/removal tool, the pumps and the lines at the relevant points for the equipment to be used (e.g. open vent plugs, pump until bubble-free air emerges, close vent plugs).
- For hydraulic installation, screw on the tool with the piston retracted.
- For hydraulic removal, screw on the tool with the piston extended.

For a hydraulic installation/removal tool with central expansion pressure supply, screw spindle into shaft end until correct sealing is established.

During hydraulic installation and removal, ensure that nobody is standing in the immediate vicinity of the component to be installed/removed.

Working on electrical/electronic assemblies

Always obtain the permission of the person in charge before commencing maintenance and repair work or switching off any part of the electronic system required to do so.

De-energize the appropriate areas prior to working on assemblies.

Do not damage cabling during removal work. When reinstalling ensure that wiring is not damaged during operation by contact with sharp objects, by rubbing against other components or by a hot surface.

Do not secure cables on lines carrying fluids.

Do not use cable binders to secure cables.

Always use connector pliers to tighten connectors.

Subject the device or system to a function check on completion of all repair work.

Store spare parts properly prior to replacement, i.e. protect them against moisture in particular. Pack defective electronic components and assemblies in a suitable manner when dispatched for repair, i.e. particularly protected against moisture and impact and wrapped in antistatic foil if necessary.

Working with laser equipment

When working with laser equipment, always wear special laser-protection goggles ⇒ Heavily focused radiation.

Laser equipment must be fitted with the protective devices necessary for safe operation according to type and application.

TIM-ID: 0000000879 - 023

For conducting light-beam procedures and measurement work, only the following laser devices must be used:

- Laser devices of classes 1, 2 or 3A.
- Laser devices of class 3B, which have maximum output in the visible wavelength range (400 to 700 nm), a maximum output of 5 mW, and in which the beam axis and surface are designed to prevent any risk to the eyes.

TIM-ID: 0000000879 - 023

1.6 Auxiliary materials, fire prevention and environmental protection

Fire prevention

Rectify any fuel or oil leaks immediately; even splashes of oil or fuel on hot components can cause fires - therefore always keep the engine in a clean condition. Do not leave cloths soaked with fluids and lubricants lying on or near the assembly or unit. Do not store inflammable material near the assembly or unit.

Do not weld pipes and components carrying oil or fuel! Before welding, clean with a nonflammable fluid.

When starting the engine with an external power source, connect the ground lead last and remove it first. To avoid sparks in the vicinity of the battery, connect the ground lead from the external power source to the ground lead of the engine or to the ground terminal of the starter.

Always keep suitable firefighting equipment (fire extinguishers) at hand and familiarize yourself with their use.

Noise

Noise can lead to an increased risk of accident if acoustic signals, warning shouts or noises indicating danger are drowned.

Wear ear protectors in work areas with a sound pressure level in excess of 85 dB (A).

Environmental protection and disposal

Modification or removal of mechanical or electronic components or the installation of additional components as well as the execution of calibration processes that might affect the emission characteristics of the engine are prohibited by emission regulations. Emission control units/systems may only be maintained, exchanged or repaired if the components used for this purpose are approved by MTU or equivalent components. Noncompliance with these guidelines might represent a violation of the Clean Air Act and involves the termination of the operating license by the emission authorities. MTU does not accept any liability for violations of the emission regulations. MTU will provide assistance and advice if emission-relevant components are intended to be modified. The MTU Maintenance Schedules ensure the reliability and performance of MTU engines and must be complied with over the entire life cycle of the engine.

Use only fuel of prescribed quality to comply with emission limit values.

Dispose of used fluids, lubricants and filters in accordance with local regulations.

Within the EU, batteries can be returned free of charge to MTU FN / MTU Onsite Energy where they are subjected to proper recycling procedures.

Auxiliary materials, fluids and lubricants

Use only fluids and lubricants that have been tested and approved by MTU.

Keep fluids and lubricants in suitable, properly designated containers. When using fluids, lubricants and other chemical substances, follow the safety instructions that apply to the product. Take special care when using hot, chilled or caustic materials. When using flammable materials, avoid all sparks and do not smoke.

Used oil

Used oil contains harmful combustion residues.

Rub barrier cream into hands.

Wash hands after contact with used oil.

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Lead

- When working with lead or lead-containing compounds, avoid direct contact to the skin and do not inhale lead vapors.
- Adopt suitable measures to avoid the formation of lead dust.
- Switch on extraction system.
- Wash hands after contact with lead or lead-containing substances.

Compressed air

Observe special safety precautions when working with compressed air:

- Pay special attention to the pressure level in the compressed air network and pressure vessel.
- Assemblies and equipment to be connected must either be designed for this pressure, or, if the permitted pressure for the connecting elements is lower than the pressure required, a pressure reducing valve and safety valve (set to permitted pressure) must form an intermediate connection.
- Hose couplings and connections must be securely attached.
- Wear goggles when blowing off components or blowing away chips.
- Provide the snout of the air nozzle with a protective disk (e.g. rubber disk).
- First shut off compressed air lines before compressed air equipment is disconnected from the supply line, or before equipment or tool is to be replaced.
- Unauthorized use of compressed air, e.g. forcing flammable liquids (danger class AI, AII and B) out of containers, results in a risk of explosion.
- Forcing compressed air into thin-walled containers (e.g. containers made of tin, plastic and glass) for drying purposes or to check for leaks, results in a risk of bursting.
- Carry out leak test in accordance with the specifications.

Painting

- When painting in other than spray booths equipped with extractors, ensure good ventilation. Make sure that neighboring work areas are not impaired.
- No open flames.
- No smoking.
- Observe fire prevention regulations.
- Always wear a mask providing protection against paint and solvent vapors.

Liquid nitrogen

- Store liquid nitrogen only in small quantities and always in regulation containers without fixed covers.
- Avoid body contact (eyes, hands).
- Wear protective clothing, protective gloves, closed shoes and protective goggles / safety mask.
- Make sure that working area is well ventilated.
- Avoid all knocks and jars to the containers, fixtures or workpieces.

Acids and alkaline solutions

- When working with acids and alkaline solutions, wear protective goggles or face mask, gloves and protective clothing.
- If such solutions are spilled onto clothing, remove the affected clothing immediately.
- Rinse injured parts of the body thoroughly with clean water.
- Rinse eyes immediately with eyedrops or clean tap water.

TIM-ID: 0000000880 - 015

1.7 Conventions for safety instructions in the text

DANGER	In the event of immediate danger. **Consequences: Death or serious injury** • Remedial action
WARNING	In the event of potentially dangerous situations. **Consequences: Death or serious injury** • Remedial action
CAUTION	In the event of dangerous situations. **Consequences: Minor injury or material damage** • Remedial action
NOTICE	In the event of a situation involving potentially adverse effects on the product. **Consequences: Material damage.** • Remedial action • Additional product information

Note: This manual contains highlighted safety warnings in accordance with the US ANSI Z535 standard which begin with one of the signal words listed above depending on the severity of the hazard.

Safety instructions

1. Read and familiarize yourself with all safety notices before starting up or repairing the product.
2. Pass on all safety instructions to your operating, maintenance, repair and transport personnel.

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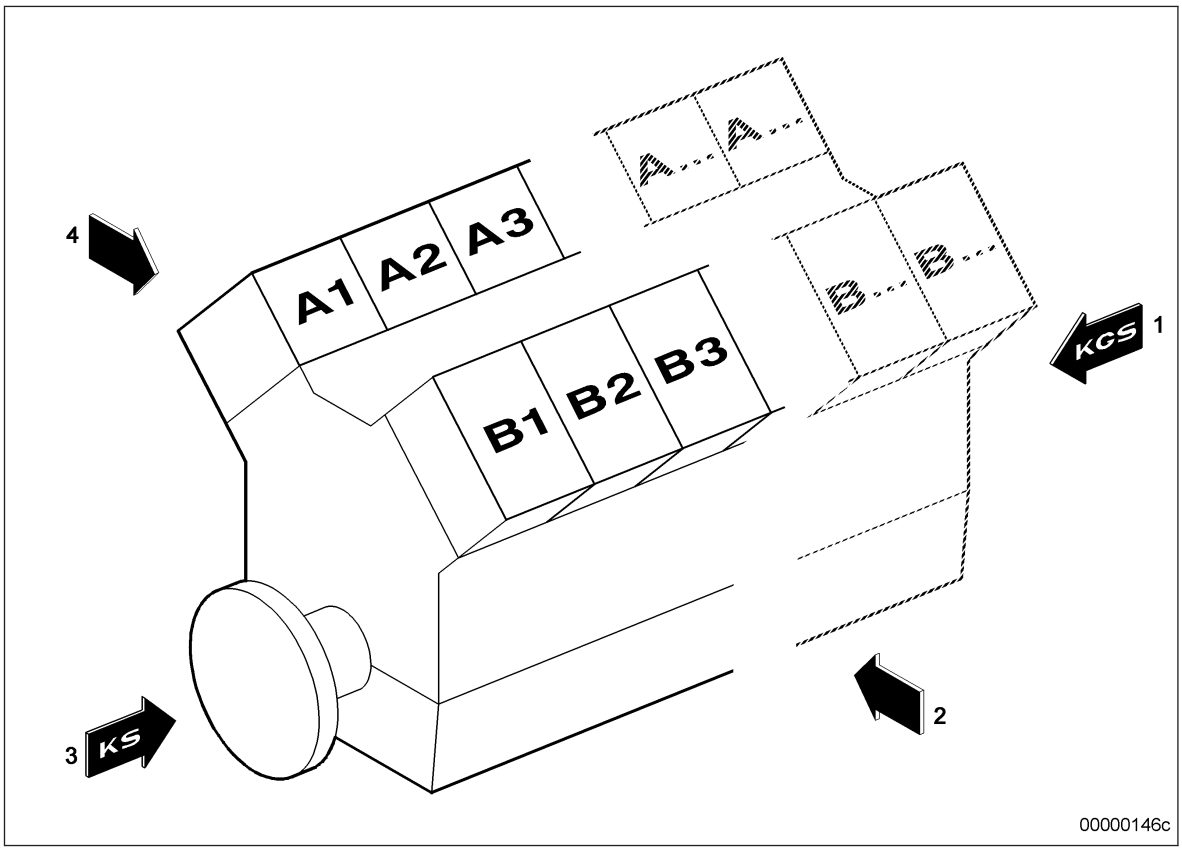
2 General Information

2.1 Engine side and cylinder designations

Engine sides are always designated as viewed from the driving end (KS).

The cylinders of the left engine side are designated "A" and those of the right side "B" (as per DIN ISO 1204). The cylinders of each bank are numbered consecutively, starting with No. 1 at the driving end of the engine.

Other components are numbered in the same way, i.e. starting with No. 1 on driving end.



1 KGS = Free end
2 Right engine side
3 KS = Driving end
4 Left engine side

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2.2 Product description

Description of the engine

Engine

The engine is a liquid-cooled four-stroke diesel engine with c.c.w. direction of rotation, direct injection, sequential turbocharging and charge-air cooling.

An electronic management system provides engine control and monitoring.

Fuel system with common rail injection

Controlled by the engine electronics, the common rail injection system determines injection pressure, injection timing and injection quantity independently of the engine speed.

Injection pressures up to 1800 bar ensure optimum fuel injection and combustion conditions.

Charging system

The charging system comprises charge-air system, exhaust system and sequential turbocharging.

The exhaust system is equipped with triple-walled, water-cooled exhaust lines.

The triple-walled design permits
- low surface temperature,
- reduced thermal load,
- absolute gas-tightness.

Lube oil system

Wet-sump forced-feed lubrication system

Components supplied with oil:
- Bearings
- Piston cooling
- Control and actuating elements of the sequential turbocharging system

Cooling system

- Two separate cooling circuits:
  - Engine coolant
  - Raw water
- Coolant cooling by raw water-cooled plate-core heat exchanger
- Thermostat-controlled coolant system
- Coolant-cooled / preheated charge air
- Coolant-cooled fuel return

Electronic system

Electronic control and monitoring system with integrated security and test system with interfaces to remote control system (RCS) and to monitoring system (MCS).

Electronic engine control unit (ECU)

Closed-loop control:
- Engine speed
- Fuel HP

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Open-loop control:
- Injection (fuel pressure, injection timing, injection duration, operating status)
- Sequential turbocharging (cutting-in and out) with secondary turbocharger
- Engine protection with multi-stage safety systems:
  - Power reduction
  - Power limitation
  - Emergency stop

Monitoring:
- Exhaust gas temperature, A-side
- Exhaust temperature, B-side
- Engine speed
- Oil pressure
- Differential oil pressure
- Coolant temperature
- Coolant level
- Exhaust turbocharger speed
- Leak fuel level
- Oil temperature
- Coolant pressure
- Fuel pressure after filter

Monitoring in engine room

Engine control and monitoring unit (LOP)

Functions:
- Engine speed, oil pressure and coolant temperature are monitored and displayed
- Integrated safety system
- Integrated test system
- Redundant CAN bus interface to governor and higher-level control and monitoring system
- 24 V DC power supply

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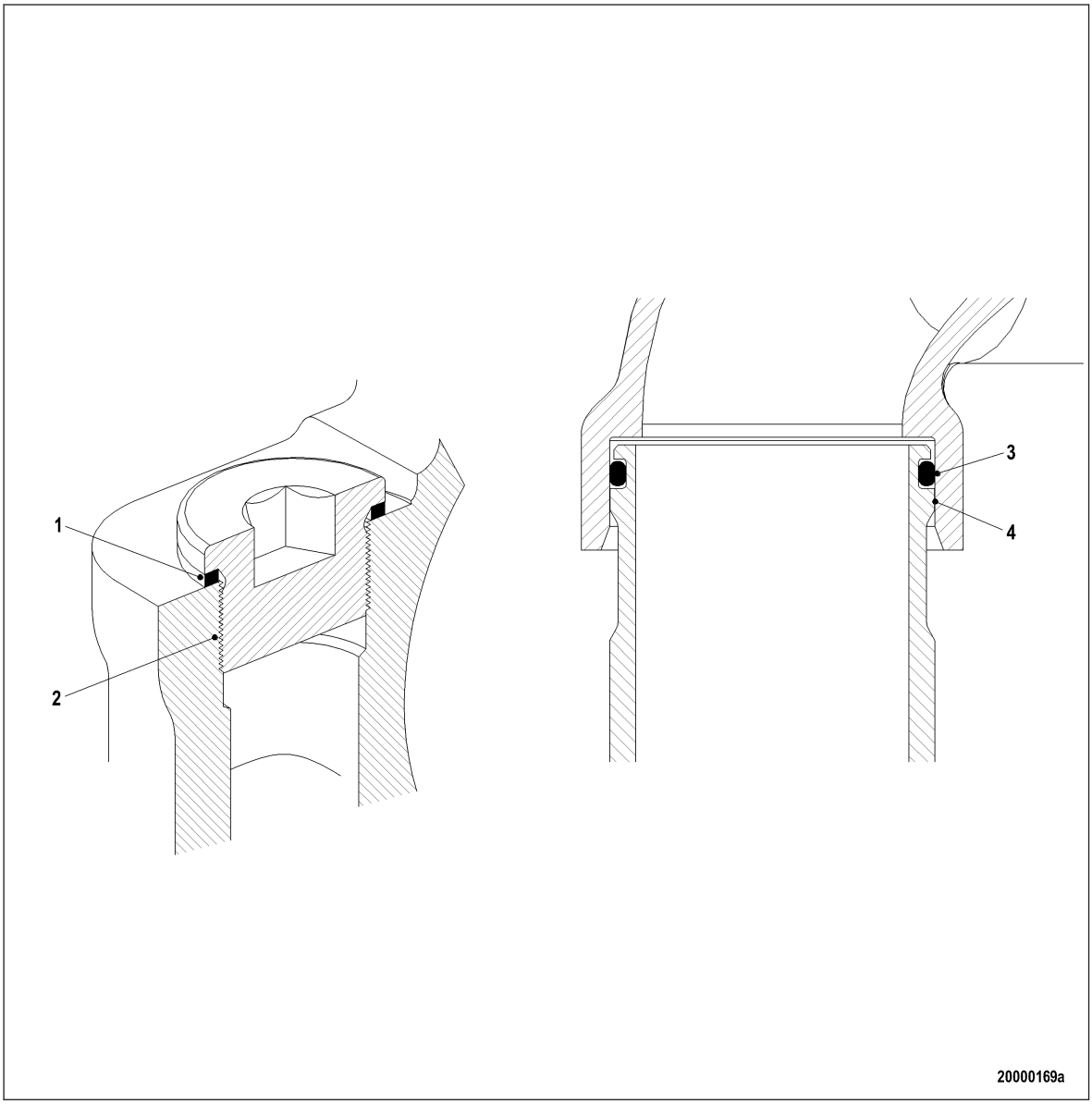
SOLAS – Fire protection specifications

Special connections



In case of leakage, the above-mentioned connection types are spray-protected even without a cover and have been confirmed compliant with SOLAS by GL and DNV.

Plug-in pipe connection

The sleeve (4) covers the joint to prevent lateral spray.

Only leak-off along the line is possible, the pressure is decreased significantly if an O-ring (3) defect occurs.

The connection is confirmed as compliant with SOLAS by DNV and GL.

Plugs and sensors

Screw-in plugs (2) are sealed toward the outside either with a copper sealing ring (1), according to DIN, or an O-ring (ISO).

In case of a loose single-ended union or a defective sealing ring (2), the liquid first has to pass the thread.

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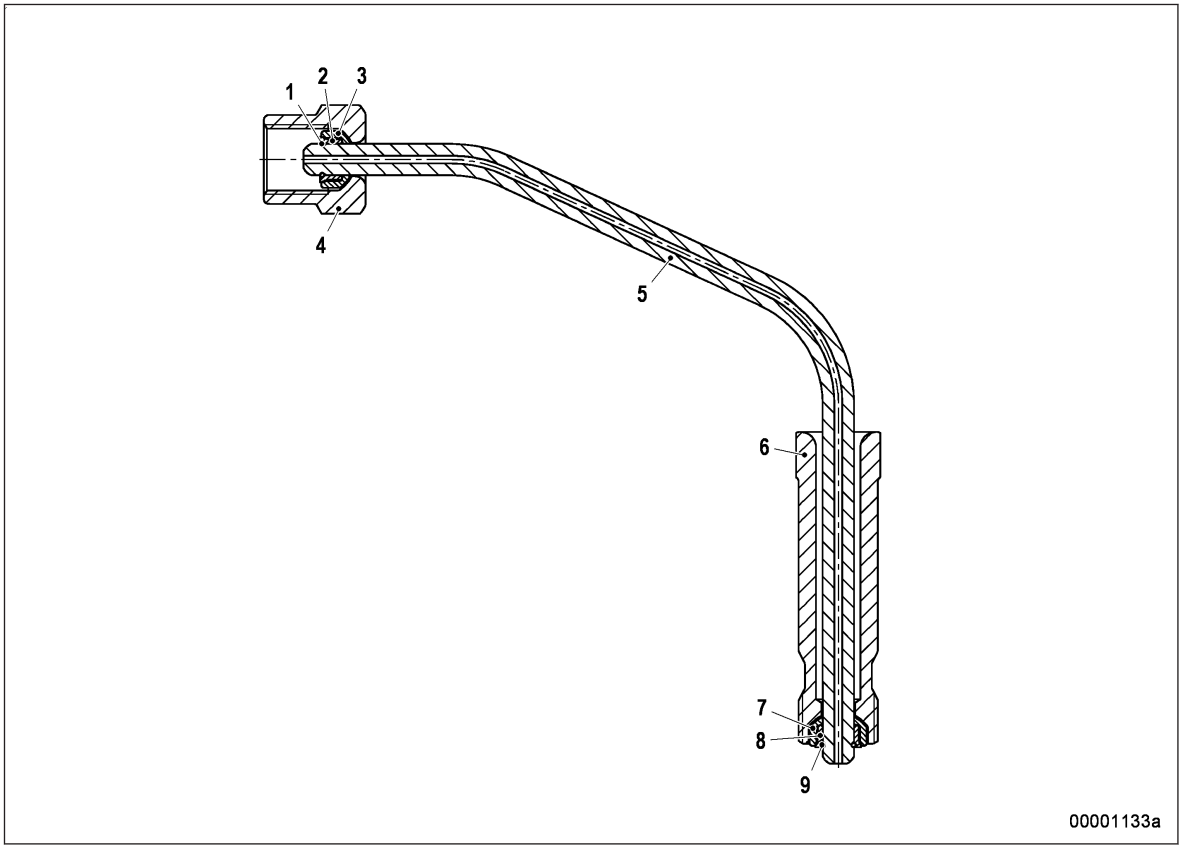
The pressure is so greatly reduced by this and the faulty sealing ring (2) that any leakage is not under pressure.

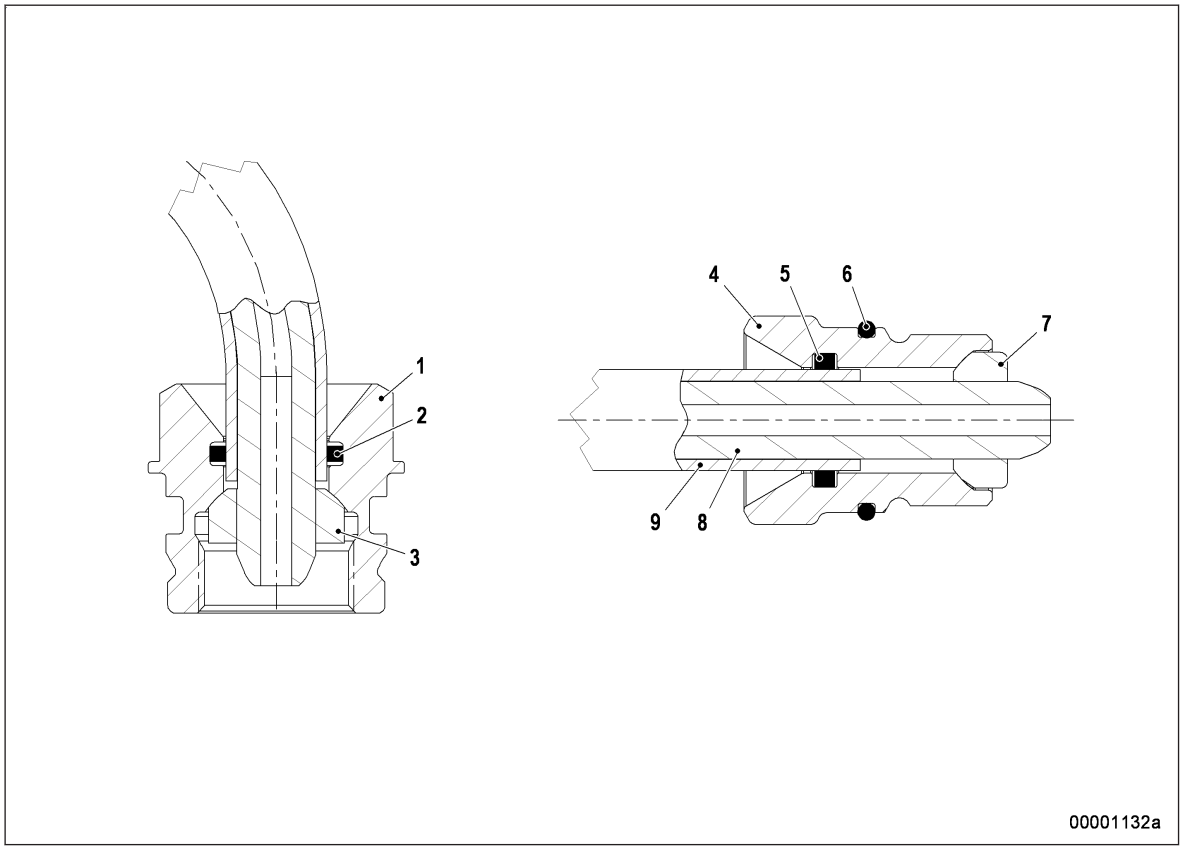
HP line between fuel injector and HP accumulator



1 Support ring
2 V-ring
3 Thrust ring
4 Union nut
5 HP line
6 Thrust screw
7 Thrust ring
8 V-ring
9 Support ring

TIM-ID: 0000002177 - 002

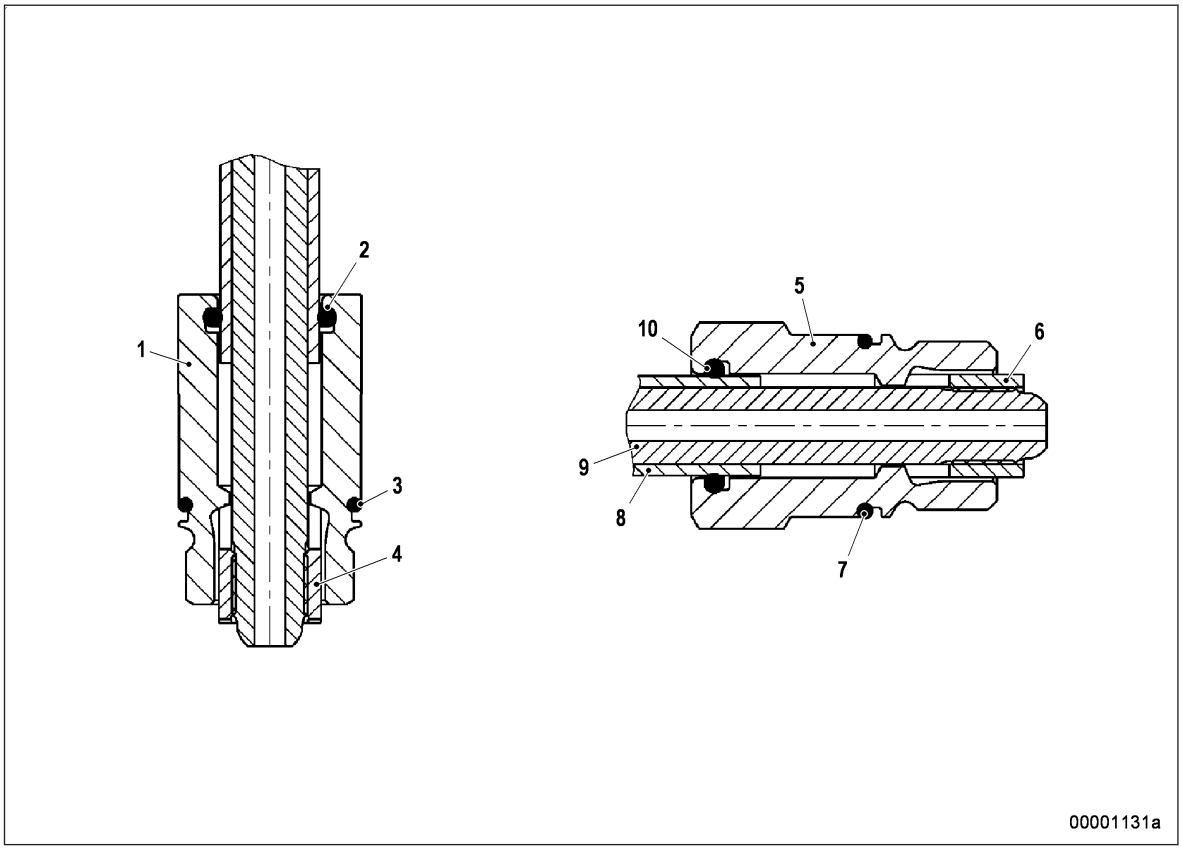
HP line between distributor and HP accumulator



1 Union nut
2 O-ring
3 Thrust ring
4 Thrust screw
5 O-ring
6 O-ring
7 Thrust ring
8 Pressure pipe
9 Jacket pipe

TIM-ID: 0000002177 - 002

HP line between distributor and HP accumulator



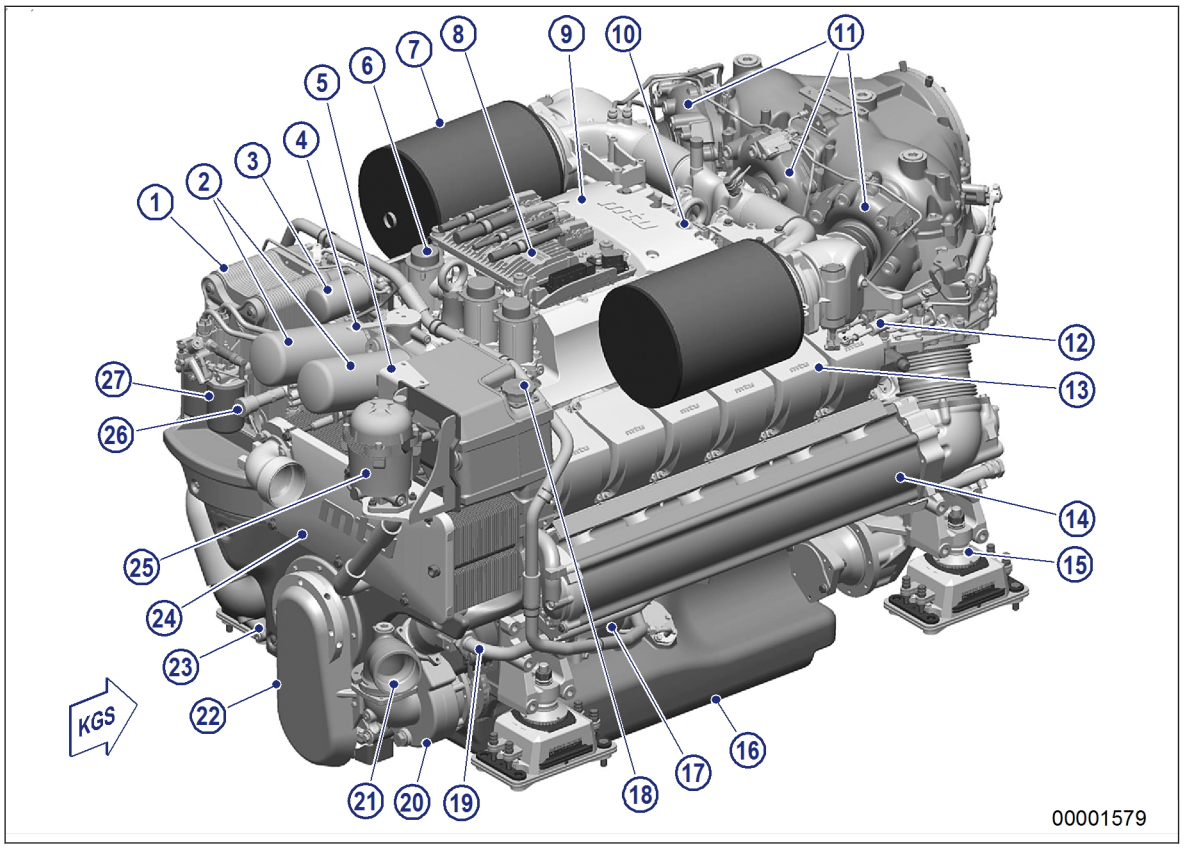
1 Jacket pipe
2 O-ring
3 O-ring
4 Thrust ring
5 Thrust screw
6 Thrust ring
7 O-ring
8 HP line
9 Pressure pipe
10 O-ring

Leak fuel caused by leakages from the sealing cones or the HP lines is returned to the HP pump, from where it is routed at atmospheric pressure into a level-monitored leak fuel tank.

TIM-ID: 0000002177 - 002

2.3 Engine - Overview

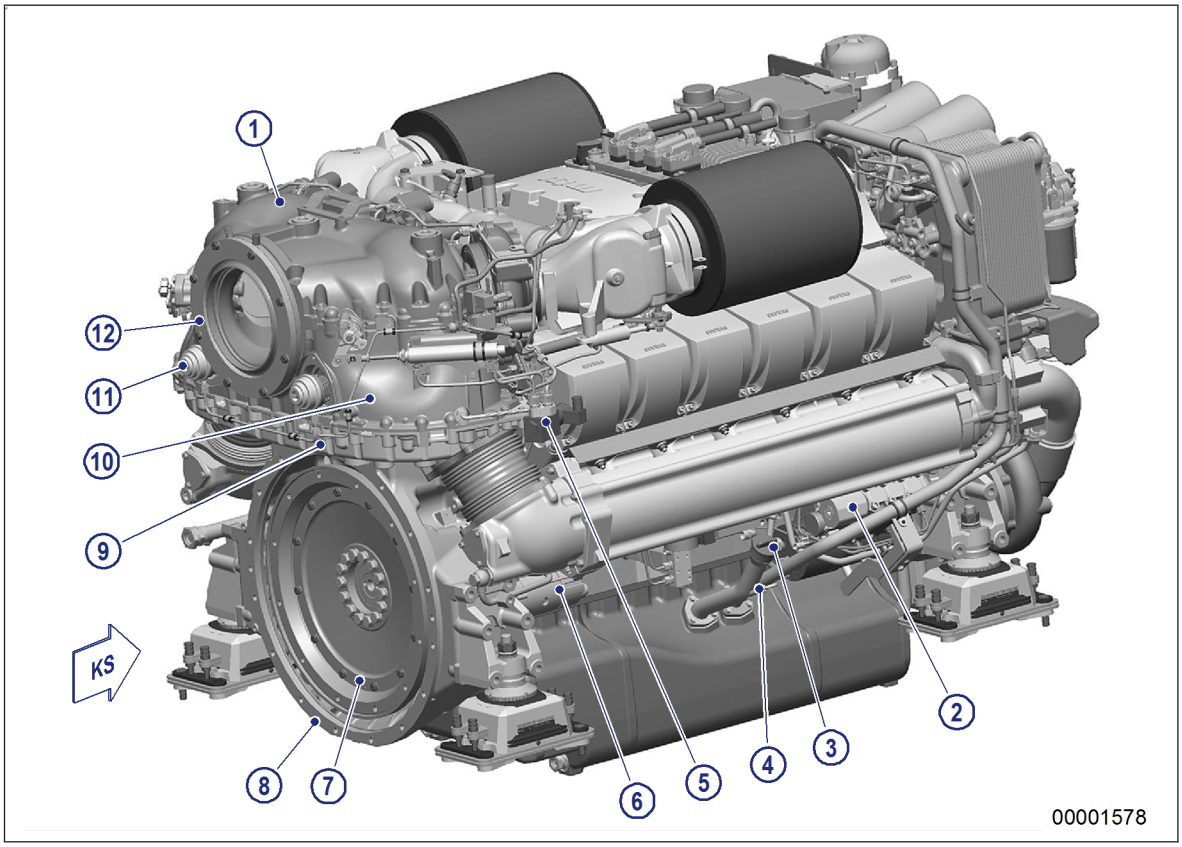
Overview of free end



1 Engine oil heat exchanger
2 Engine oil filter
3 Coolant filter
4 Diverter lever for engine oil filter
5 Coolant distribution housing with integrated expansion tank
6 Oil separator
7 Air filter (air intake)
8 Engine governor
9 Air collecting housing
10 Engine lifting eyes
11 Exhaust turbocharger
12 Actuating cylinder for exhaust flap
13 Carrier housing
14 Cylinder head cover
15 Engine mounting
16 Oil pan
17 Battery-charging generator
18 Coolant filler neck
19 Raw water connection to gearbox cooling system
20 Raw water pump
21 Raw water connection from sea
22 Protective cover (belt pulley)
23 Coolant pump
24 Plate-core heat exchanger
25 Centrifugal oil filter
26 Fuel priming pump
27 Fuel filter
KGS = engine free end

TIM-ID: 0000009987 - 003

Overview driving end



1 Carrier housing upper section
2 HP fuel pump
3 Oil filler neck
4 Oil dipstick
5 4/2-way directional control valve
6 Electric starter
7 Drive flange
8 Flywheel housing
9 Carrier housing lower section
10 Carrier housing middle section
11 Bleeder valve
12 Exhaust outlet
KS = engine driving end

Engine model designation

Key to the engine model designation 12V/16V 2000 Mxy	
12/16	Number of cylinders
v	Cylinder arrangement
2000	Series
Mx	Application segment
y	Design index

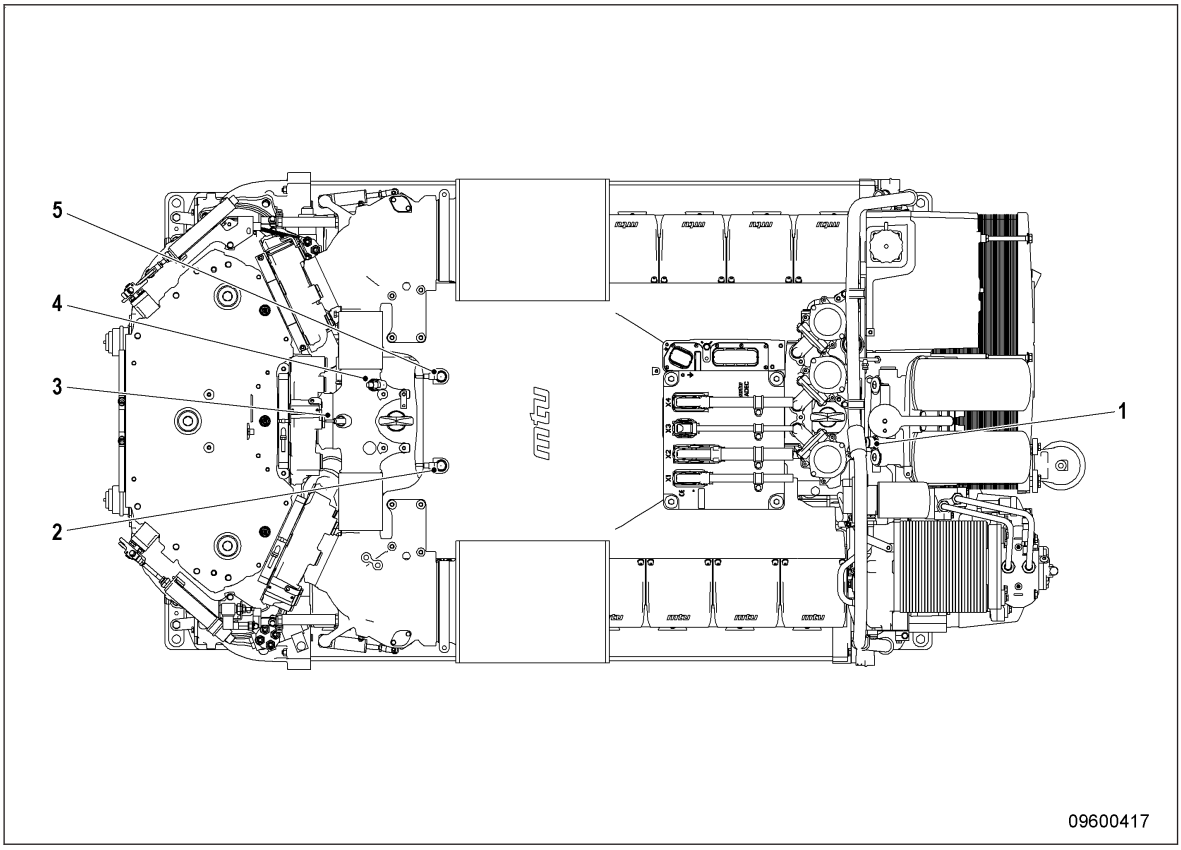
TIM-ID: 0000009987 - 003

2.4 Sensors, actuators and injectors – Overview

Engine plan view

Deviations from illustrations are insignificant.

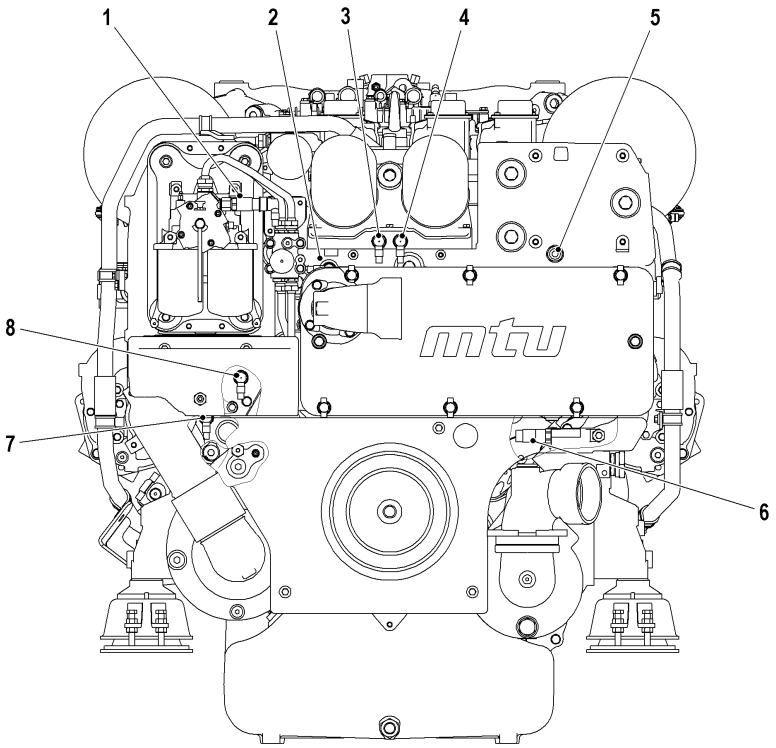
Also applies similarly to 12V.



Item	Description	Monitoring of
1	B7	Lube oil temperature
2	B10	Charge-air pressure
3	B44	Turbocharger speed
4	B3	Intake air temperature
5	B9	Charge-air temperature

TIM-ID: 0000008412 - 003

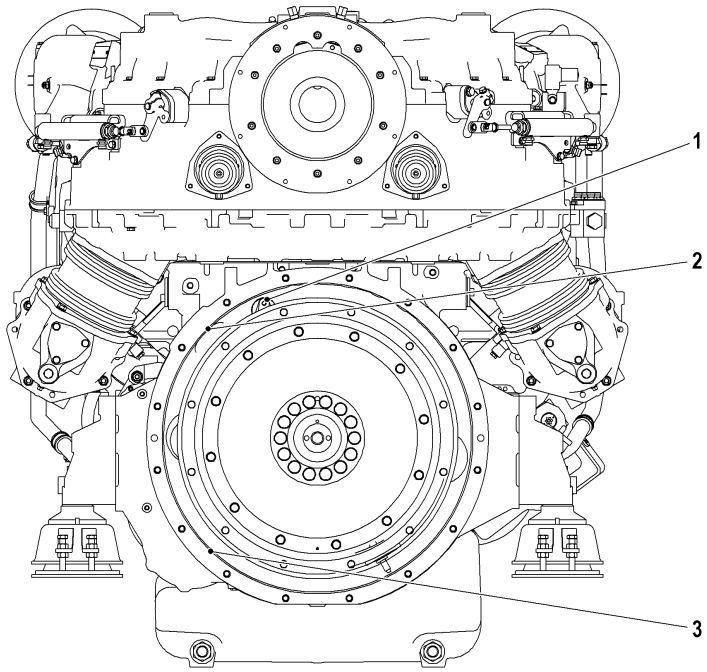
Engine free end



Item	Description	Monitoring of
1	B34	Fuel pressure after filter
2	B5.3 (option)	Lube oil pressure before filter
3	B5.1	Lube oil pressure after filter
4	B5.2 (option)	Lube oil pressure after filter
5	F33	Engine coolant level, expansion tank
6	B21 (option)	Raw water pressure
7	B6.2 (option)	Coolant temperature
8	B6.1	Coolant temperature

TIM-ID: 0000008412 - 003

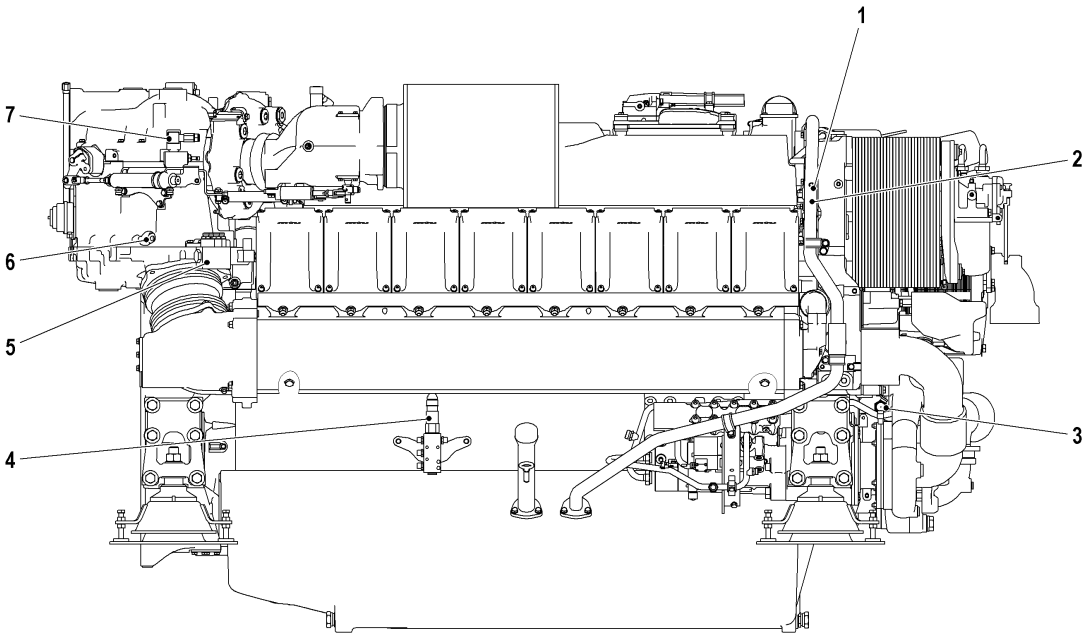
Engine driving end



Item	Description	Monitoring of
1	B1 (ECU)	Camshaft speed
2	B13.2 (optional EMU)	Crankshaft speed
3	B13 (ECU)	Crankshaft speed

TIM-ID: 0000008412 - 003

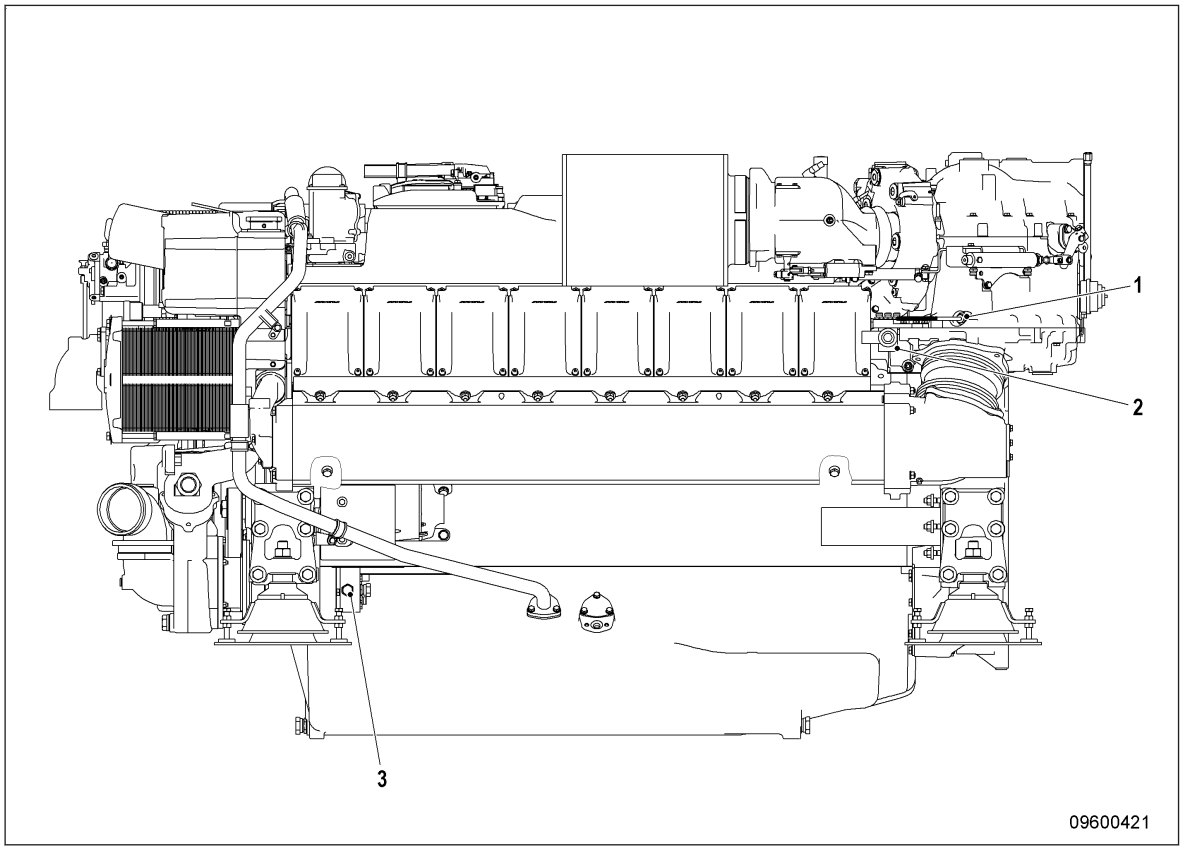
Engine, right side



Item	Description	Monitoring of
1	YB33	Fuel temperature
2	B48	Fuel pressure (in rail)
3	B16 (option)	Coolant pressure
4	F46	Leak fuel level
5	Y27.2	4-2-directional control valve, B-side
6	B4.22	Exhaust temperature, B-side
7	F41	2-2-directional control valve

TIM-ID: 0000008412 - 003

Engine, left side



Item	Description	Monitoring of
1	B4.21	Exhaust gas temperature, A-side
2	Y27.1	4-2-directional control valve, A-side
3	B54 (option)	Lube oil pressure, replenishment pump

System sensors

These sensors are fitted outside the engine.

Description	Monitoring of
B19	Starting-air pressure
B70	Fuel prefilter water level
B41	Exhaust back pressure
S37	Start interlock, switching status

TIM-ID: 0000008412 - 003

3 Technical Data

3.1 12V 2000 M94 engine data

Explanation:

CP Reference value: Continuous power
FP Reference value: Fuel stop power
A Design value
G Guaranteed value
R Guideline value
L Limit value, up to which the engine can be operated, without change (e.g. of power setting)
N Not yet defined value
- Not applicable
X Applicable

REFERENCE CONDITIONS

Engine model			12V2000 M94
Application group			1DS
Intake air temperature		°C	25
Raw water inlet temperature		°C	25
Barometric pressure		mbar	1000
Site altitude above sea level		m	100

POWER-RELATED DATA (power ratings are net brake power as per ISO 3046)

Number of cylinders			12
Rated engine speed	A	rpm	2450
Fuel stop power ISO 3046	A	kW	1432

GENERAL CONDITIONS (for maximum power)

Number of cylinders			12
Intake depression (new filter)	A	mbar	15
Intake depression, max.	L	mbar	30

MODEL RELATED DATA (basic design)

Number of cylinders			12
Cylinder arrangement: V angle		Degrees (°)	90
Bore		mm	135
Stroke		mm	156
Cylinder displacement		Liters	2.23
Displacement, total		Liters	26.76
Number of inlet valves per cylinder			2
Number of exhaust valves per cylinder			2

TIM-ID: 0000010852 - 002

RAW WATER CIRCUIT (open circuit)

Number of cylinders			12
Raw water pump: Inlet pressure, min.	L	bar	-0.4
Raw water pump: inlet pressure, max.	L	bar	+0.5
Pressure loss in engine-external raw water system, max.	L	bar	0.7

LUBE OIL SYSTEM

Number of cylinders			12
Lube oil operating temperature upstream of engine, from	R	°C	82
Lube-oil operating temperature upstream of engine, to	R	°C	92
Lube oil operating pressure upstream of engine, from	R	bar	7.5
Lube oil operating pressure upstream of engine, to	R	bar	8.5
Lube oil operating pressure (low idle) (meas. point: upstream of engine)	R	bar	3

FUEL SYSTEM

Number of cylinders			12
Fuel pressure at engine inlet connection, min. (when engine is starting)	L	bar	-0.3
Fuel pressure at engine inlet connection, min. (when engine is running),	L	bar	-0.3
Fuel pressure at engine inlet connection, max. (when engine is starting)	L	bar	+0.25
Fuel supply flow, max.	R	liters/min	7.1

GENERAL OPERATING DATA

Number of cylinders			12
Firing speed, from	R	rpm	100
Firing speed, to	R	rpm	120

STARTER (electric)

Number of cylinders			12
Rated starter voltage (standard design)	R	V=	24

INCLINATIONS, STANDARD OIL SYSTEM (reference: waterline)

Number of cylinders			12
Longitudinal inclination, continuous max. driving end down (Option: max. operating inclinations)	L	Degrees (°)	15
Longitudinal inclination, temporary max. driving end down (Option: max. operating inclinations)	L	Degrees (°)	22.5
Longitudinal inclination, continuous max. driving end up (Option: max. operating inclinations)	L	Degrees (°)	0
Longitudinal inclination, temporary max., driving end up (Option: max. operating inclinations)	L	Degrees (°)	10
Transverse inclination, continuous max. (Option: max. operating inclinations)	L	Degrees (°)	22.5
Transverse inclination, temporary max. (Option: max. operating inclinations)	L	Degrees (°)	32.5

TIM-ID: 0000010852 - 002

CAPACITIES

Number of cylinders			12
Engine coolant, engine side (with cooling system)	R	Liters	125
Engine oil capacity, initial filling (standard oil system) (Option: max. operating inclinations)	R	Liters	123
Oil change quantity, max. (standard oil system) (Option: max. operating inclinations)	R	Liters	113
Oil pan capacity at dipstick mark “min.” (standard oil system) (Option: max. operating inclinations)	L	Liters	87
Oil pan capacity at dipstick mark “max.” (standard oil system) (Option: max. operating inclinations)	L	Liters	105

WEIGHTS / MAIN DIMENSIONS

Number of cylinders			12
Engine dry weight (with attached standard accessories, without coupling)	R	kg	2780

NOISE

Number of cylinders			12
Exhaust noise, unsilenced - BL (free-field sound pressure level Lp, 1m distance, ISO 6798, +3dB(A) tolerance)	R	dB(A)	109
Engine surface noise with attenuated intake noise (filter) - BL (free-field sound power level Lp, 1 m distance, ISO 6798, +2dB(A) tolerance)	R	dB(A)	104

TIM-ID: 0000010852 - 002

3.2 16V 2000 M94 engine data

Explanation:

CP Reference value: Continuous power
FP Reference value: Fuel stop power
A Design value
G Guaranteed value
R Guideline value
L Limit value, up to which the engine can be operated, without change (e.g. of power setting)
N Not yet defined value
- Not applicable
X Applicable

REFERENCE CONDITIONS

Engine model			16V2000 M94
Application group			1DS
Intake air temperature		°C	25
Raw water inlet temperature		°C	25
Barometric pressure		mbar	1000
Site altitude above sea level		m	100

POWER-RELATED DATA (power ratings are net brake power as per ISO 3046)

Number of cylinders			16
Rated engine speed	A	rpm	2450
Fuel stop power ISO 3046	A	kW	1939

GENERAL CONDITIONS (for maximum power)

Number of cylinders			16
Intake depression (new filter)	A	mbar	15
Intake depression, max.	L	mbar	30

MODEL RELATED DATA (basic design)

Number of cylinders			16
Cylinder arrangement: V angle		Degrees (°)	90
Bore		mm	135
Stroke		mm	156
Cylinder displacement		Liters	2.23
Displacement, total		Liters	35.68
Number of inlet valves per cylinder			2
Number of exhaust valves per cylinder			2

TIM-ID: 0000010887 - 002

RAW WATER CIRCUIT (open circuit)

Number of cylinders			16
Raw water pump: Inlet pressure, min.	L	bar	-0.4
Raw water pump: inlet pressure, max.	L	bar	+0.5
Pressure loss in engine-external raw water system, max.	L	bar	0.7

LUBE-OIL SYSTEM

Number of cylinders			16
Lube oil operating temperature upstream of engine, from	R	°C	75
Lube-oil operating temperature upstream of engine, to	R	°C	94
Lube oil operating pressure upstream of engine, from	R	bar	6.0
Lube oil operating pressure upstream of engine, to	R	bar	7.5
Lube oil operating pressure (low idle) (meas. point: upstream of engine)	R	bar	2.5

FUEL SYSTEM

Number of cylinders			16
Fuel pressure at engine inlet connection, min. (when engine is starting)	L	bar	-0.3
Fuel pressure at engine inlet connection, min. (when engine is running),	L	bar	-0.3
Fuel pressure at engine inlet connection, max. (when engine is starting)	L	bar	+0.25
Fuel supply flow, max.	R	liters/min	8.6

GENERAL OPERATING DATA

Number of cylinders			16
Firing speed, from	R	rpm	100
Firing speed, to	R	rpm	120

STARTER (electric)

Number of cylinders			16
Rated starter voltage (standard design)	R	V=	24

INCLINATIONS, STANDARD OIL SYSTEM (reference: waterline)

Number of cylinders			16
Longitudinal inclination, continuous max. driving end down (Option: max. operating inclinations)	L	Degrees (°)	15
Longitudinal inclination, temporary max. driving end down (Option: max. operating inclinations)	L	Degrees (°)	22.5
Longitudinal inclination, continuous max. driving end up (Option: max. operating inclinations)	L	Degrees (°)	0
Longitudinal inclination, temporary max., driving end up (Option: max. operating inclinations)	L	Degrees (°)	10
Transverse inclination, continuous max. (Option: max. operating inclinations)	L	Degrees (°)	22.5
Transverse inclination, temporary max. (Option: max. operating inclinations)	L	Degrees (°)	32.5

TIM-ID: 0000010887 - 002

CAPACITIES

Number of cylinders			16
Engine coolant, engine side (with cooling system)	R	Liters	135
Engine oil capacity, initial filling (standard oil system) (Option: max. operating inclinations)	R	Liters	168
Oil change quantity, max. (standard oil system) (Option: max. operating inclinations)	R	Liters	155
Oil pan capacity at dipstick mark “min.” (standard oil system) (Option: max. operating inclinations)	L	Liters	115
Oil pan capacity at dipstick mark “max.” (standard oil system) (Option: max. operating inclinations)	L	Liters	138

WEIGHTS / MAIN DIMENSIONS

Number of cylinders			16
Engine dry weight (with installed standard accessories, without coupling)	R	kg	3337

NOISE

Number of cylinders			16
Exhaust noise, unsilenced - BL (free-field sound pressure level Lp, 1m distance, ISO 6798, +3dB(A) tolerance)	R	dB(A)	110
Engine surface noise with attenuated intake noise (filter) - BL (free-field sound power level Lp, 1 m distance, ISO 6798, +2dB(A) tolerance)	R	dB(A)	107

TIM-ID: 0000010887 - 002

3.3 Firing order

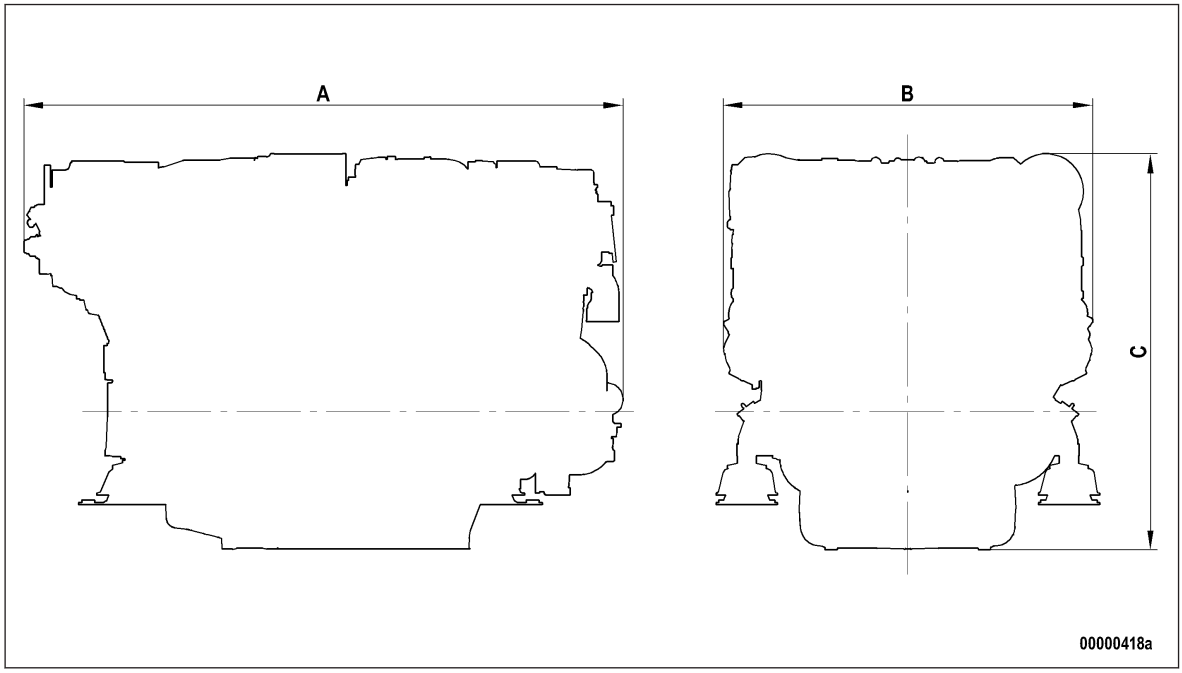
Firing order

8V	A1-B4-A4-A2-B3-A3-B2-B1
10 V	A1-B4-A4-B3-A3-B2-A2-B5-A5-B1
12 V	A1-B5-A5-B3-A3-B6-A6-B2-A2-B4-A4-B1
16 V	A1-B5-A3-A5-B2-B8-A2-A8-B3-A7-B4-B6-A4-A6-B1-B7

TIM-ID: 0000002801 - 003

3.4 Engine – Main dimensions

Main dimensions



Engine model	Length (A)	Width (B)	Height (C)
8V 2000 M72	approx. 1683 mm	approx. 1147 mm	approx. 1200 mm
8V 2000 M92	approx. 1683 mm	approx. 1147 mm	approx. 1200 mm
8V 2000 M93	approx. 1683 mm	approx. 1147 mm	approx. 1200 mm
8V 2000 M84	approx. 1683 mm	approx. 1147 mm	approx. 1200 mm
8V 2000 M94	approx. 1683 mm	approx. 1147 mm	approx. 1200 mm
10V 2000 M72	approx. 1860 mm	approx. 1147 mm	approx. 1320 mm
10V 2000 M92	approx. 1860 mm	approx. 1147 mm	approx. 1320 mm
10V 2000 M93	approx. 1860 mm	approx. 1147 mm	approx. 1320 mm
10V 2000 M84	approx. 1860 mm	approx. 1147 mm	approx. 1320 mm
10V 2000 M94	approx. 1860 mm	approx. 1147 mm	approx. 1320 mm
12V 2000 M92	approx. 2069 mm	approx. 1295 mm	approx. 1350 mm
12V 2000 M93	approx. 2069 mm	approx. 1295 mm	approx. 1350 mm
12V 2000 M84	approx. 2094 mm	approx. 1295 mm	approx. 1350 mm
12V 2000 M94	approx. 2094 mm	approx. 1295 mm	approx. 1350 mm
16V 2000 M92	approx. 2486 mm	approx. 1295 mm	approx. 1390 mm
16V 2000 M93	approx. 2486 mm	approx. 1295 mm	approx. 1390 mm
16V 2000 M84	approx. 2511 mm	approx. 1295 mm	approx. 1390 mm
16V 2000 M94	approx. 2511 mm	approx. 1295 mm	approx. 1390 mm

TIM-ID: 0000002153 - 002

4 Operation

4.1 Putting the engine into operation after extended out-of-service periods (>3 months)

Preconditions

☑ Engine is stopped and starting disabled.

☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

Putting the engine into operation (out-of-service period > 3 months)

Item	Measure
Engine	Depreserve (→ MTU Fluids and Lubricants Specifications A001061/..).
Lube oil system	Check engine oil level (→ Page 97).
Fuel prefilter	Fill with fuel (→ Page 90).
Fuel prefilter, pressure gauge	Align adjustable pointer with position of pressure indicator (→ Page 86).
Fuel system	Vent (→ Page 83).
Raw-water pump (if located above waterline)	Prime (approx. 3 to 4 liters). Filling point (→ Page 104).
Coolant circuit	If engine is out of service for more than one year, change engine coolant (→ Page 111).
Coolant circuit	Check coolant level (→ Page 110).
Coolant circuit	Heat engine coolant with coolant preheating unit.

TIM-ID: 0000002213 - 002

4.2 Engine – Putting into operation after scheduled out-of-service-period

Preconditions

☑ Engine is stopped and starting disabled.

Putting into operation

Item	Measure
Lube oil system	Check engine oil level (→ Page 97).
Coolant circuit	Check coolant level (→ Page 110).
Coolant circuit	Heat engine coolant with coolant preheating unit.
Fuel prefilter	Drain water and contaminants (→ Page 87).
Battery-charging generator drive	Check condition of drive belt (→ Page 118).

TIM-ID: 0000002689 - 002

4.3 Tasks after extended out-of-service periods (>3 weeks)

Tasks after extended out-of-service periods (>3 weeks)

Note: Operate fuel treatment system for at least 5 minutes.

1. Start up fuel treatment system (→ Page 45).
2. Shut down fuel treatment system (→ Page 53).

TIM-ID: 0000007730 - 005

4.4 Checks prior to start-up

Checks prior to start-up

1. Check tank and the entire pipework for cleanness. If microorganisms are detected:
   a) Clean affected components.
   b) Disinfect affected components with biocides (→ MTU Fluids and Lubricants Specifications A001061/..).
2. Close drain valves on housing.
3. Open all supply and discharge valves.
4. Switch on fuel treatment system (→ Page 48).
5. Check direction of rotation of pump.
6. Vent bypass and fuel lines of the system.
   a) Open ball valve for pressure tank.
   b) Open ball valve for overflow tank.
   c) Close ball valve at the inlet to the fuel treatment system.

Result: Bypass line is vented via the overflow tank.

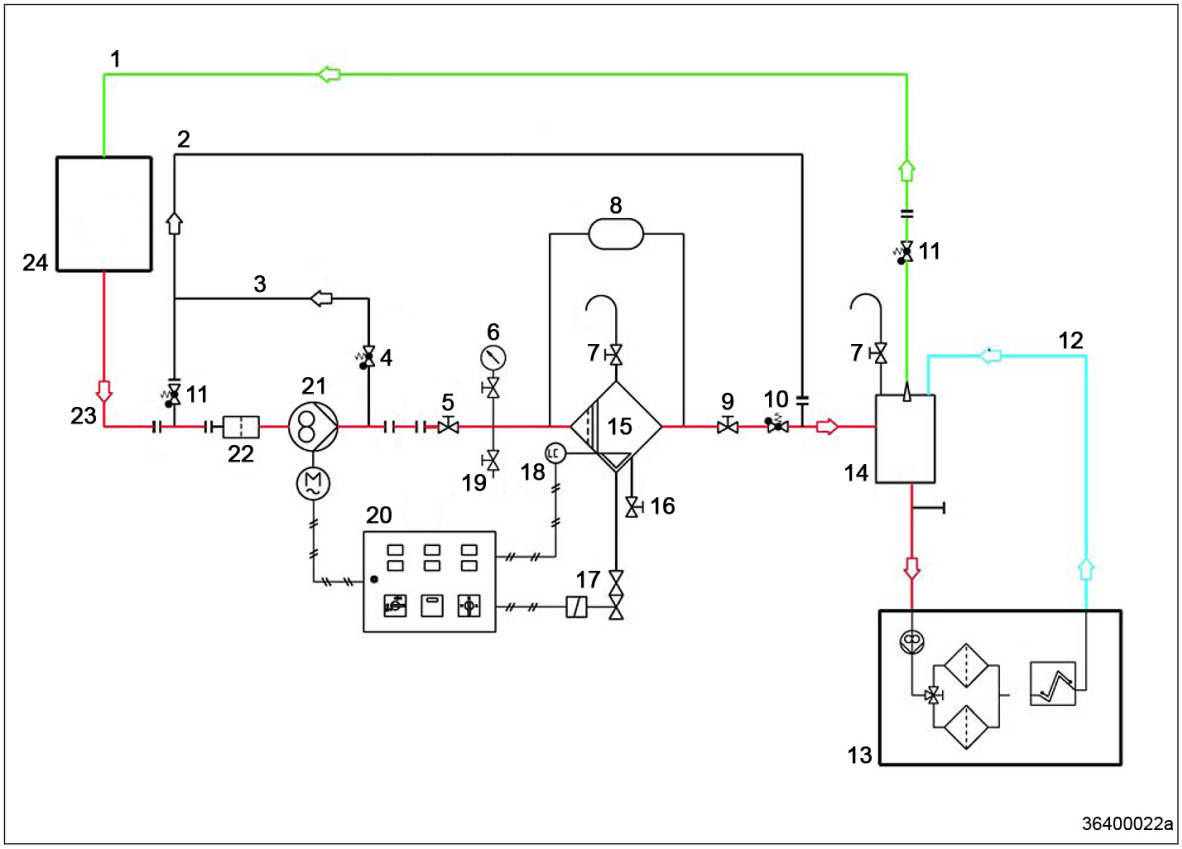
   d) Open ball valve at the inlet to the fuel treatment system.
7. Check the fuel treatment system for leaks.

Result: The fuel treatment system is ready for operation.

TIM-ID: 0000007736 - 005

4.5 Fuel treatment system – Putting into operation

Fuel treatment system – Overview



1. Switch on fuel treatment system (→ Page 48).
2. Check the differential pressure at differential pressure gauge (8). Differential pressure in a new system: 0.1 bar to 0.3 bar.

Result: If no differential pressure is measured, the coalescer filter element is probably being bypassed.
1. Remove coalescer filter element (→ Page 124).
2. Check sealing faces on coalescer filter element and in the pressure tank.

Initial operation: HAT

1. Replace fuel filter on engine (→ Page 84).

Note: Determine the suction pressure upstream of the engine-mounted fuel delivery pump.
2. Install a pressure gauge in the fuel supply line from the shipyard-side fuel system to the engine.
3. Switch on fuel treatment system and operate it for some minutes (→ Page 48).

Result: Fuel is sucked from the tank, dirt particles and water are filtered and separated, then the fuel is delivered via the overflow tank back to the tank. Water which has settled in the tank is separated.
4. Start engine (→ Page 49).
5. Run engine at idling speed.
6. Check suction pressure (see technical data of the engine) at the engine-mounted fuel delivery pump.

Note: If the suction pressure is within the permissible limits and engine operation is satisfactory:
7. Increase engine speed to 1000 rpm and monitor suction pressure.
8. Check suction pressure at the engine-mounted fuel delivery pump.

Result: If the values are within the limits specified by the manufacturer, the system is ready to start filter replacement simulation with the engine running as part of the Harbor Acceptance Tests.

TIM-ID: 0000007738 - 005

Simulation of filter replacement with the engine running: HAT

1. Switch on fuel treatment system (→ Page 48).
2. Start engine (→ Page 49).
3. Run engine at idling speed.
4. Close ball cock (5) at the inlet to the fuel treatment system.

Result: The pressure upstream of the fuel treatment system increases until the overflow valve at the pump unit opens and fuel flows through bypass (3) and bypass (2).

5. Open ball cock (19).

Result: Fuel emerges. If no fuel emerges:
- Open ball cock (5) at the inlet to the fuel treatment system.
- No function of bypasses (2) and (3); carry out functional test of bypasses (2) and (3).

6. Check suction pressure (see technical data of the engine) at the fuel delivery pump.

Note: If the suction pressure is within the permissible limits and engine operation is satisfactory:

7. Increase engine speed to 1000 rpm and monitor suction pressure.

Result: If all engine operating values are within the specified limits, open ball cock (5) at the inlet to the fuel treatment4 system.

Simulation of power failure (emergency): HAT

1. Switch on fuel treatment system (→ Page 48).
2. Start engine (→ Page 49).
3. Run engine at idling speed.
4. Switch off pump (21) on switch cabinet.

Result: The engine-mounted fuel delivery pump sucks fuel via bypass (2) directly from the tank.

5. Check suction pressure at the engine-mounted fuel delivery pump.

Note: If the suction pressure is within the permissible limits and engine operation is satisfactory.

6. Increase engine speed to 1000 rpm and monitor suction pressure.

Result: If the suction pressure is within the specified limits, simulation was successful.

Simulation of power failure (emergency): SAT

1. Switch on fuel treatment system (→ Page 48).
2. Start engine (→ Page 49).
3. Run engine at idling speed.
4. Switch off pump (21) on switch cabinet.

Result: The engine-mounted fuel delivery pump sucks fuel via bypass (2) directly from the tank.

5. Check suction pressure at the engine-mounted fuel delivery pump.

Note: If the suction pressure is within the permissible limits and engine operation is satisfactory:

6. Operate engine at full load and monitor suction pressure.

Result: If the suction pressure is within the specified limits, simulation was successful.

TIM-ID: 0000007738 - 005

4.6 Operational checks

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Operational checks

Item	Measure
Engine under load	Visually inspect engine for leaks and general condition;
Engine at nominal speed	Check for abnormal running noises and vibration;
	Check exhaust color (→ Page 57).
Fuel prefilter	Check if suction-side pressure indicated at the fuel prefilter pressure gauge is within the limit (→ Page 86).
	Drain water and contaminants (→ Page 87).
Air filter	Check signal ring position of service indicator (→ Page 95).
HT coolant pump	Check relief bore for oil and coolant discharge and contamination (→ Page 114).
Raw water pump	Check relief bore for oil and water discharge and contamination (→ Page 117).
Intercooler	Check condensate drain (if applicable) (→ Page 92).
Engine oil	Check engine oil level (→ Page 97).

TIM-ID: 0000002274 - 005

4.7 Fuel treatment system – Switching on

Preconditions

☑ The on-board power supply is switched on.

CAUTION

Damage to engine/plant.
Major material damage!
- Before switching on, ensure that the engine/plant is ready for operation.
- Before switching on, ensure that all housings are closed.
- Before switching on, ensure that no work is in progress anywhere on the entire system.

Switching on fuel treatment system

1. Carry out checks prior to start-up (→ Page 44).
2. Switch on master switch on switch cabinet.

Result: Signal lamp “Control voltage present” lights up.

3. Switch on switch for pump.

Result: Signal lamp “Pump running” lights up.

TIM-ID: 0000007731 - 005

4.8 Starting the engine

Preconditions

☑ External start interlock is not activated.

☑ Emergency air shut-off flaps (if fitted) are open.

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Before barring or starting the engine, make sure that nobody is in the danger zone.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

The engine can be started from the following points :

1. (→ Operating instructions for electronic system)
2. Commanding control stand (→ Operating instructions for electronic system);
3. Local operating panel LOP (→ Operating instructions for electronic system);
4. Local Operation Station LOS (→ Operating instructions for electronic system);
5. CCU (→ Operating instructions for electronic system).

TIM-ID: 0000002240 - 002

4.9 Stopping the engine

Preconditions

☑ Engine is running in local mode.

CAUTION

Stopping the engine when it is running at full load causes extreme stress to the engine.
Risk of overheating, damage to components!
- Before shutting down, disengage gear and run the engine at idle speed for at least 10 mins. until engine temperatures have dropped and constant values are displayed.

The engine can be stopped from the following points :

1. (→ Operating instructions for electronic system)
2. Commanding control stand (→ Operating instructions for electronic system);
3. Local operating panel LOP (→ Operating instructions for electronic system);
4. Local Operation Station LOS (→ Operating instructions for electronic system);
5. CCU (→ Operating instructions for electronic system).

TIM-ID: 0000002298 - 002

4.10 Emergency stop

CAUTION

An emergency stop causes extreme stress to the engine.
Risk of overheating, damage to components!
- Initiate emergency stop only in emergency situations.

An emergency stop of the engine can be initiated from the following points :

1. (→ Operating instructions for electronic system)
2. Commanding control stand (→ Operating instructions for electronic system);
3. Local operating panel LOP (→ Operating instructions for electronic system);
4. Local Operation Station LOS (→ Operating instructions for electronic system);
5. CCU (→ Operating instructions for electronic system).

TIM-ID: 0000002312 - 002

4.11 After stopping the engine

Preconditions

☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

After stopping the engine

Item	Action
Coolant circuit	Drain coolant (→ Page 112) if: • freezing temperatures are expected and the engine is to remain out of service for an extended period, but engine coolant has no antifreeze additive; • the engine room is not heated; • the coolant is not kept at a suitable temperature; • the antifreeze concentration is insufficient for the engine-room temperature; • antifreeze concentration is 50 % and engine-room temperature is below -40 °C.
Raw water	Drain • If freezing temperatures are to be expected and the engine is to remain out of service for an extended period.
Engine control system	Switch off.
Air intake and exhaust system	Out-of-service-period > 1 week • Seal engine's air and exhaust sides.
Engine	Out-of-service-period > 1 month • Preserve engine (→ MTU Fluids and Lubricants Specifications A001061/..)

TIM-ID: 0000002324 - 007

4.12 Fuel treatment system – Shutdown

Shutting down fuel treatment system

1. Press the illuminated pushbutton "Water drain" on the switch cabinet until water discharge from the outlet stops.
2. Switch off fuel treatment system.
3. Close ball valve at the inlet to the fuel treatment system.
4. Close ball valve at the outlet of the fuel treatment system.
5. Open drain valve until pressure has escaped from fuel treatment system.

TIM-ID: 0000007732 - 005

4.13 Plant – Cleaning

Preconditions

☑ Engine is stopped and starting disabled.

☑ Operating voltage is not applied.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Steam jet cleaner	-	1
Cleaner (Hakupur 312)	30390	1

WARNING

Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

WARNING

Water jet.
Risk of injury and scalding!
- Do not direct water jet at persons.
- Wear protective clothing, gloves, and goggles / safety mask.

CAUTION

Excessive reaction time of cleaning agents on components.
Damage to component!
- Observe manufacturer's instructions.
- Wear protective clothing, gloves, and goggles / safety mask.

Note: There is a risk of damaging sensors with compressed air.

Plant – Cleaning

1. Carry out plant cleaning only in areas where an appropriate oil separator is provided (environmental protection).
2. Prior to putting the cleaning unit into operation, read the Operating Instructions of the water/steam jet unit carefully and observe the safety precautions.
3. For external cleaning with high-pressure jet, use a flat-mouth nozzle only.
4. Carry out external cleaning as follows:
   a) Remove coarse dirt.
   b) Spray on cleaner sparingly and leave it for 1 to 5 minutes.
   c) Use the high-pressure jet to remove the loosened dirt.
   d) During external cleaning of the plant with water/steam-jet units, the pressure of the high-pressure jet (cleaning jet) must not exceed 50 bar. A minimum distance between spray nozzle and plant of 1 m must be observed. The temperature of the cleaning medium must not exceed 80 °C.

TIM-ID: 0000010171 - 021

5 Maintenance

5.1 Maintenance task reference table [QL1]

The maintenance tasks and intervals for this product are defined in the Maintenance Schedule. The Maintenance Schedule is a stand-alone publication.

The task numbers in this table provide reference to the maintenance tasks specified in the Maintenance Schedule.

Task	Maintenance tasks	
W0500	Check engine oil level	(→ Page 97)
W0501	Visually inspect engine for leaks and general condition	(→ Page 47)
W0502	Check intercooler drain (if fitted)	(→ Page 92)
W0503	Check signal ring position of service indicator on air filter	(→ Page 95)
W0505	Check relief bores of coolant pump(s)	(→ Page 114)
W0506	Check engine for abnormal running noises, exhaust color and vibrations	(→ Page 47)
W0507	Drain water and contaminants from fuel prefilter (if fitted)	(→ Page 87)
W0508	Check reading on differential pressure gauge of fuel prefilter (if fitted)	(→ Page 86)
W1001	Replace fuel filter or fuel filter element	(→ Page 84)
W1002	Check valve clearance	(→ Page 76)
W1005	Replace air filter	(→ Page 93)
W1006	Replace fuel injectors	(→ Page 80)
W1008	Replace engine oil filter at each oil change or when the time limit (years) is reached, at the latest	(→ Page 99)
W1009	Check layer thickness of oil residue, clean and replace filter sleeve (if fitted) at each oil change or when the time limit (years) is reached, at the latest	(→ Page 101)
W1011	Perform endoscopic inspection of combustion chambers	(→ Page 69)
W1036	Replace coolant filter	(→ Page 116)
W1140	Clean wire meshes of crankcase breather	(→ Page 73)
W1244	Check operation of rod electrode (if fitted)	(→ Page 122)
W1245	Check alarm function of differential pressure gauge (if fitted)	(→ Page 121)
W1246	Check pump capacity (if fitted)	(→ Page 123)

Table 1: Maintenance task reference table [QL1]

TIM-ID: 0000027582 - 003

6 Troubleshooting

6.1 Fuel treatment system – Troubleshooting

Illuminated pushbutton “water alarm” is lit.

Cause	Corrective action
When the maximum water level is reached, the water level electrode opens the water drain valve and water is discharged. If the opening period of the valve exceeds a pre-set limit (4 minutes), the pump will switch off and an alarm is initiated.	1. Press illuminated pushbutton “Water alarm” to acknowledge. 2. In addition to the automatic water drain function, water can also be drained manually. To do so, press the illuminated pushbutton “Water drain” to open the drain valve.

Signal lamp “Pump fault” is lit.

Cause	Corrective action
The drive motor is equipped with an overload protection. If the maximum permissible current consumption is exceeded, e.g. in case of a blockage or dry-running, the motor protection relay triggers and the pump is switched off.	▶ Reset motor protection relay.

Signal lamp “Warning filter” is lit.

Cause	Corrective action
The differential pressure exceeded 1.3 bar.	▶ Replace coalescer filter element (→ Page 124).

Illuminated pushbutton “Replace filter element” is lit.

Cause	Corrective action
The max. permissible differential pressure of 1.5 bar was exceeded. If the coalescer filter element is not replaced, pressure will increase further and the safety valve will open. Fuel will be led via the bypass directly into the overflow tank.	1. Replace coalescer filter element (→ Page 124). 2. Press illuminated pushbutton “Replace filter element” to acknowledge.

TIM-ID: 0000028607 - 001

6.2 Troubleshooting

Engine does not turn when starter is actuated

Component	Probable Cause	Task
Battery	Low or defective	Charge or replace (see manufacturer's documentation).
	Cable connections defective	Check if cable connections are properly secured (see manufacturer's documentation).
Starter	Engine wiring or starter defective	Check if cable connections are properly secured, contact Service.
Engine wiring	Defective	Check (→ Page 126).
ECU	Plug-in connections are loose	Check plug-in connections for secure seating.
Engine	Running gear blocked (engine cannot be barred manually)	Contact Service.

Engine turns but does not fire

Component	Probable Cause	Task
Starter	Poor rotation by starter: Battery low or defective	Charge or replace battery (see manufacturer's documentation).
Engine wiring	Defective	Check (→ Page 126).
Fuel system	Not vented	Vent fuel system (→ Page 83).
ECU	Defective	Contact Service.

Engine fires unevenly

Component	Probable Cause	Task
Fuel injection equipment	Injector defective	Replace (→ Page 80).
Engine wiring	Defective	Check (→ Page 126).
Fuel system	Not vented	Vent fuel system (→ Page 83).
ECU	Defective	Contact Service.

Engine does not reach nominal speed

Component	Probable Cause	Task
Fuel supply	Fuel prefilter clogged	Replace (→ Page 90).
	Fuel filter clogged	Replace (→ Page 84).
Air supply	Air filter clogged	Check signal ring position of service indicator (→ Page 95).
Fuel injection equipment	Injector defective	Replace (→ Page 80).
Engine wiring	Defective	Check (→ Page 126).
Engine	Overloaded	Contact Service.

TIM-ID: 0000002555 - 002

Engine speed not steady

Component	Probable Cause	Task
Fuel injection equipment	Injector defective	Replace (→ Page 80).
Speed sensor	Defective	Replace.
Fuel system	Not vented	Vent fuel system (→ Page 83).
ECU	Defective	Contact Service.

Charge-air temperature too high

Component	Probable Cause	Task
Engine coolant	Incorrect coolant concentration	Check.
Intercooler	Contaminated	Contact Service.
Engine room	Air-intake temperature too high	Check fans and air supply / ventilation ducts.

Charge air pressure too low

Component	Probable Cause	Task
Air supply	Air filter clogged	Check signal ring position of service indicator (→ Page 95).
Intercooler	Contaminated	Contact Service.
Exhaust turbocharger	Defective	Contact Service.

Coolant leaks on intercooler

Component	Probable Cause	Task
Intercooler	Leaking, major coolant discharge	Contact Service.

Exhaust gas black

Component	Probable Cause	Task
Air supply	Air filter clogged	Check signal ring position of service indicator (→ Page 95).
Fuel injection equipment	Injector defective	Replace (→ Page 80).
Engine	Overloaded	Contact Service.

Exhaust gas blue

Component	Probable Cause	Task
Engine oil	Too much oil in engine	Drain engine oil (→ Page 98).
	Oil separator or oil preseparator of crankcase breather clogged	• Clean preseparator (→ Page 73). • Replace filter element of oil separator (→ Page 74).
Exhaust turbocharger, cylinder head, piston rings, cylinder liner	Defective	Contact Service.

TIM-ID: 0000002555 - 002

Exhaust gas white

Component	Probable Cause	Task
Engine	Not at operating temperature	Run engine to reach operating temperature.
Fuel system	Water in fuel	Drain fuel prefilter (→ Page 87).
Intercooler	Leaking	Contact Service.

TIM-ID: 0000002555 - 002

7 Task Description

7.1 SOLAS

7.1.1 SOLAS shielding as per MTN 5233 – Installation

Preconditions

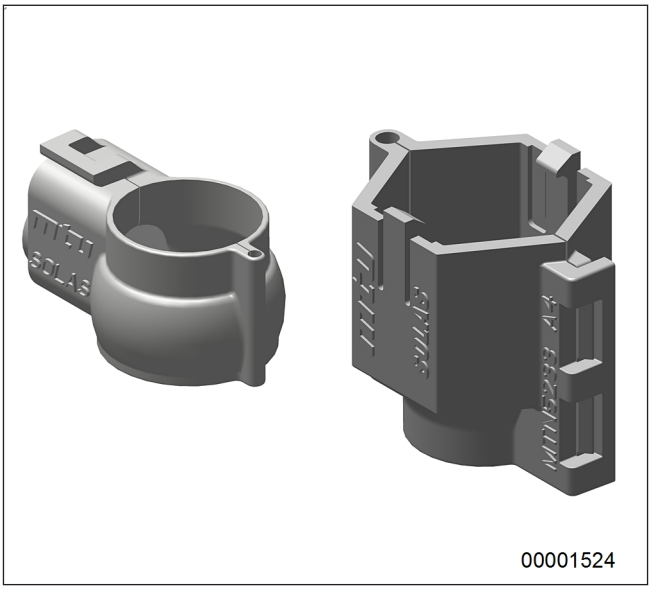
☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Shield A4	735233000100	10
Shield A5	735233000101	14
Shield A7	735233000103	6
Shield A8	735233000104	2

SOLAS shielding – Installation

1. Pinpoint installation location (→ Page 62).
2. Install suitable shielding.
3. Press shielding until locked.



00001524

TIM-ID: 0000010550 - 003

7.1.2 SOLAS- Abschirmung anbringen

Preconditions

☑ Motor abgestellt und gegen Starten gesichert.

☑ Motor auf Umgebungstemperatur abgekühlt.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Abdeckung Ölfilter	X00009628	
Abdeckung Kraftstofffilter	X00009654	

SOLAS- Abdeckung Ölfilter und Kraftstofffilter anbringen

1. Anbauort lokalisieren (→ Page 62).
2. Passende Abschirmung anbringen.

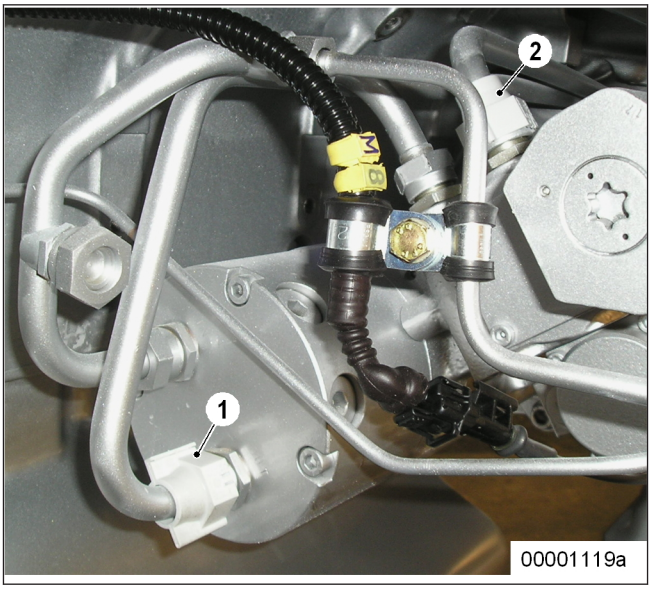
TIM-ID: 0000010702 - 004

7.1.3 Installation locations for SOLAS shielding

General information

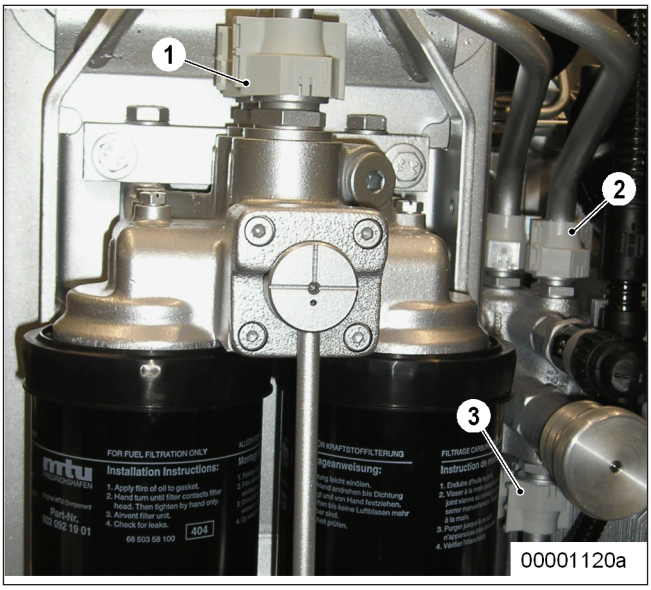
Primarily fit SOLAS shielding as per MTN 5233 (→ Page 60).

Free end B-side



Item	Type of shielding	Comments
1 (free end, B-side)	Shield (A7)	On fuel delivery pump
2 (free end, B-side)	Shield (A7)	On HP fuel pump

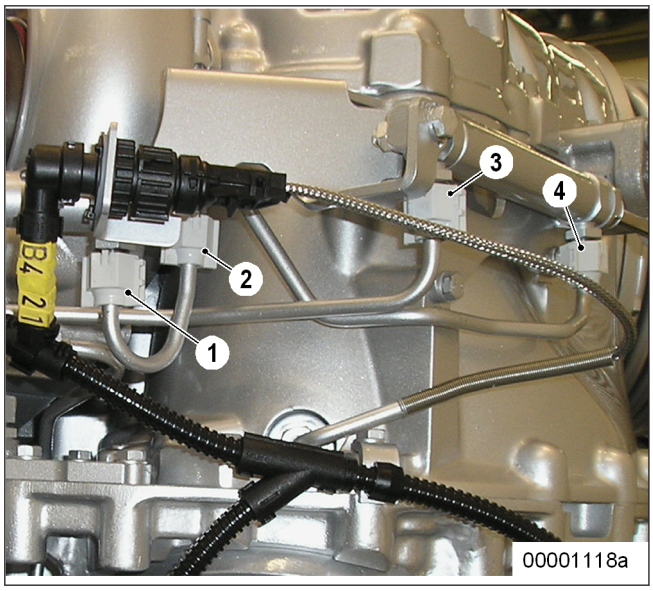
Free end



TIM-ID: 0000010064 - 005

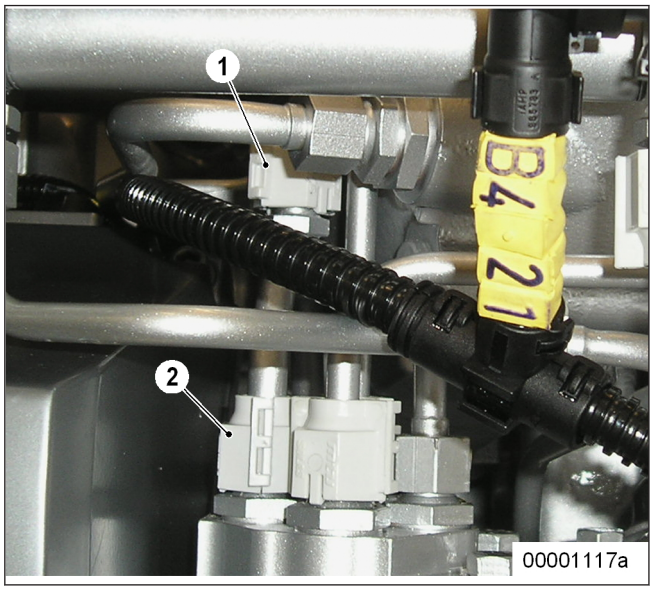
Item	Type of shielding	Comments
1 (free end)	Shield (A8)	On fuel filter
2 (free end)	Shield (A7)	Above fuel priming pump
3 (free end)	Shield (A7)	Below fuel priming pump

Driving end A-side



Item	Type of shielding	Comments
1 (Driving end, A-side)	Shield (A5)	On air flap
2 (Driving end, A-side)	Shield (A4)	On brazed-on union
3 (driving end, A-side)	Shield (A5)	On turbocharger flap
4 (driving end, A-side)	Shield (A5)	On turbocharger flap

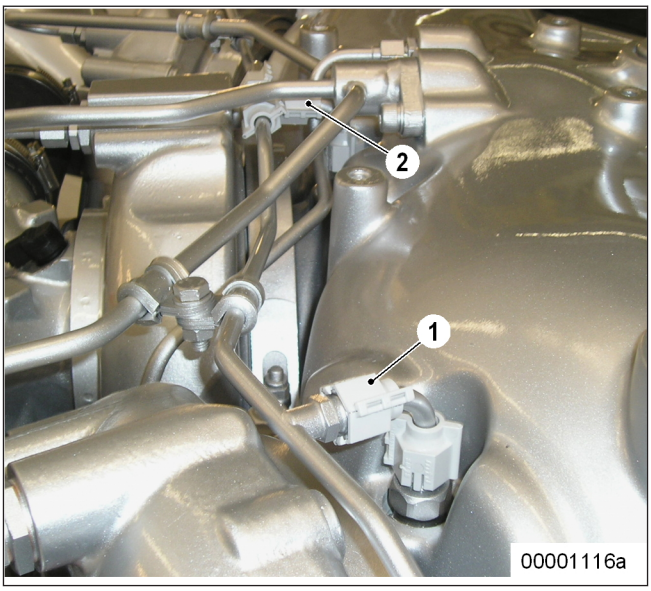
Driving end A-side



TIM-ID: 0000010064 - 005

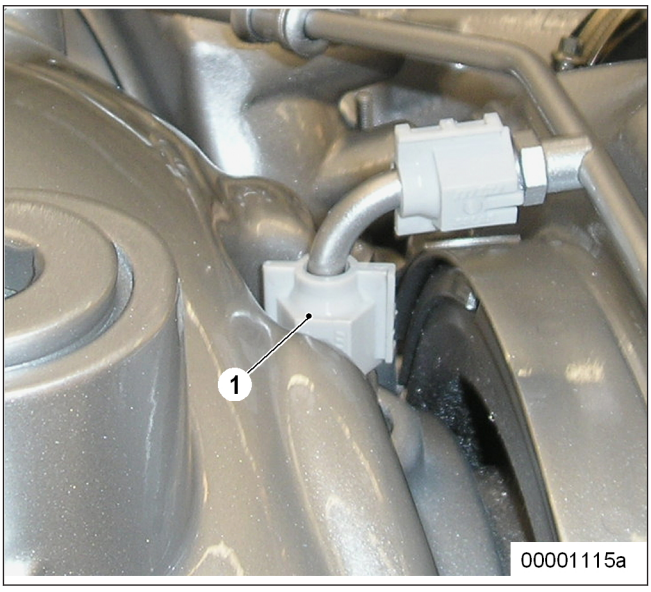
Item	Type of shielding	Comments
1 (driving end, A-side)	Shield (A5)	To turbocharger lubrication
2 (driving end, A-side)	Shield (A5)	On valve plate

Driving end



Item	Type of shielding	Comments
1 (driving end)	Shield (A4)	Turbocharger lubrication, left side
2 (driving end)	Shield (A4)	Turbocharger lubrication, center

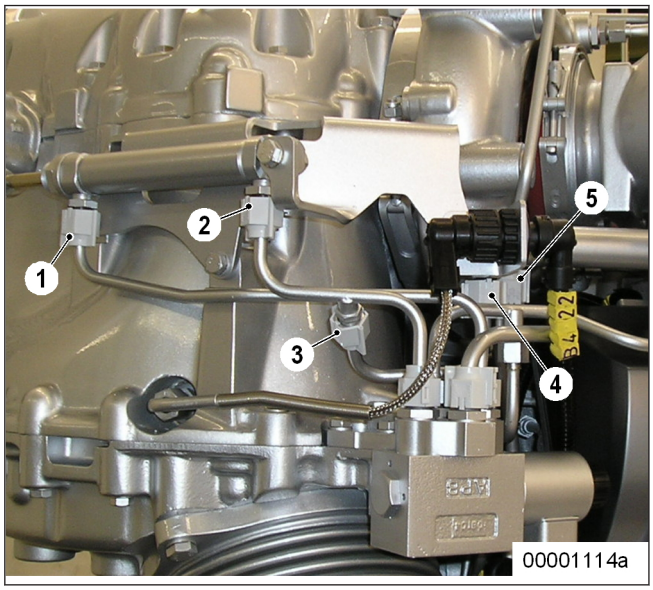
Driving end



Item	Type of shielding	Comments
1 (driving end)	Shield (A4)	Turbocharger lubrication, right side

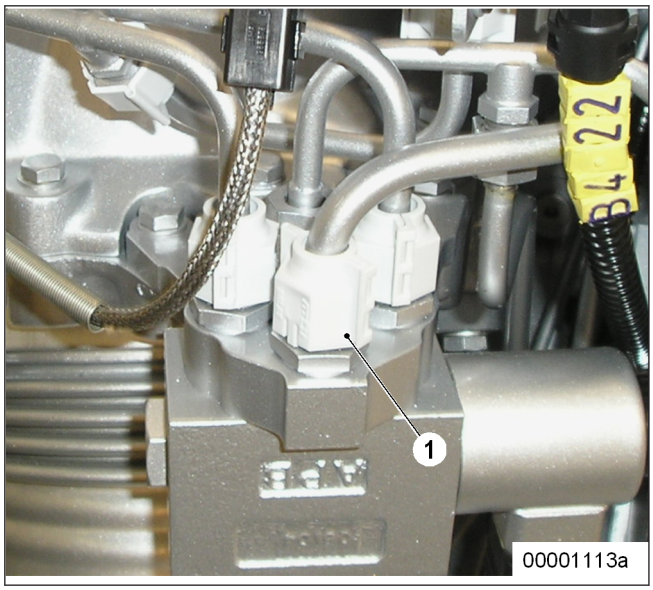
TIM-ID: 0000010064 - 005

Driving end B-side



Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	Turbocharger flap
2 (driving end, B-side)	Shield (A5)	Turbocharger flap
3 (driving end, B-side)	Shield (A4)	On brazed-on union
4 (driving end, B-side)	Shield (A5)	On air flap
5 (driving end, B-side)	Shield (A4)	To turbocharger lubrication

Driving end B-side



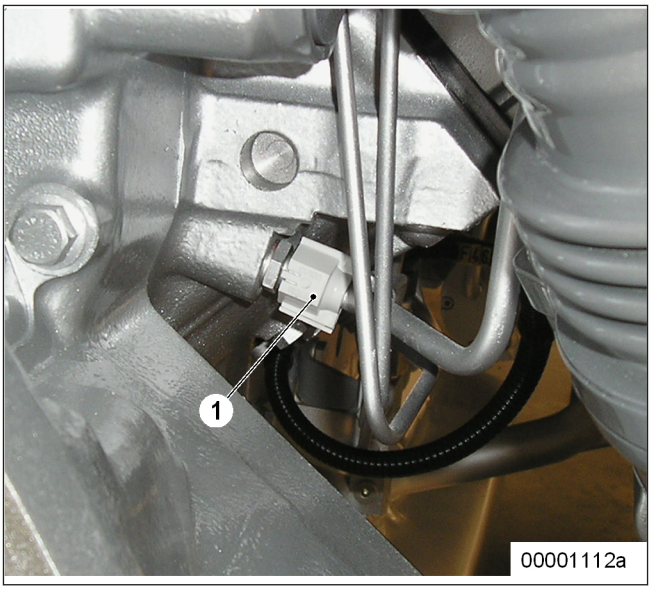
Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	On valve plate

TIM-ID: 0000010064 - 005

Driving end A-side

Item	Type of shielding	Comments
1 (driving end, A-side)	Shield (A5)	To flap control

Driving end B-side



Item	Type of shielding	Comments
1 (driving end, B-side)	Shield (A5)	To flap control

TIM-ID: 0000010064 - 005

7.2 Engine

7.2.1 Engine – Barring manually

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Barring tool	F6783914	1
Ratchet	F30006212	1

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- before barring or starting the engine, ensure that nobody is in the danger zone.
- After working on the engine, check that all protective devices have been reinstalled and all tools removed from the engine.

Engine – Barring manually

1. Fit ratchet with barring tool on barring tool connection at the vibration damper on engine free end.
2. Rotate crankshaft in engine direction of rotation. Apart from the normal compression resistance, there should be no resistance.

Result: If the resistance exceeds the normal compression resistance, contact Service.

TIM-ID: 0000002527 - 002

7.2.2 Engine – Barring with starting equipment

Preconditions

☑ Clutch is disengaged.

☑ Engine start is disabled.

☑ LOP is accessible and open.

DANGER

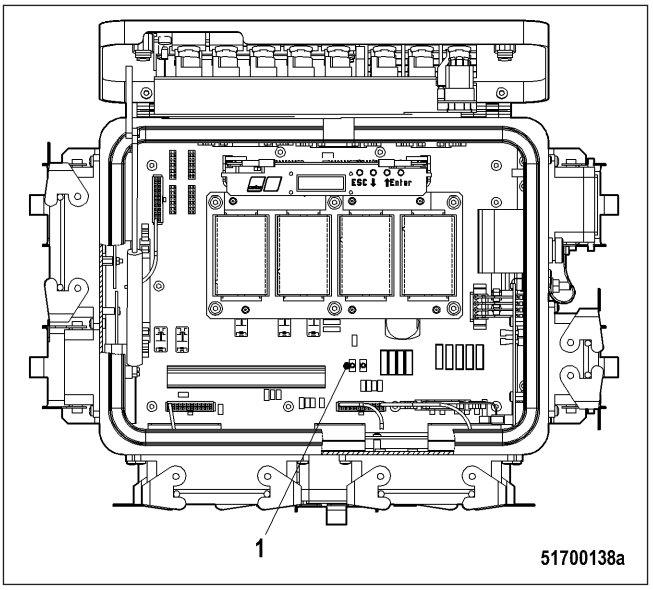
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- before barring or starting the engine, ensure that nobody is in the danger zone.
- After working on the engine, check that all protective devices have been reinstalled and all tools removed from the engine.

Barring

1. Press barring button on the LMB mother-board of the LOP and keep it depressed.

Result: Engine is barred by starter for max. 20 seconds.

2. Release barring pushbutton.



TIM-ID: 0000027968 - 001

7.3 Cylinder Liner

7.3.1 Cylinder liner – Endoscopic examination

Preconditions

☑ Engine is stopped and starting disabled

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Rigid endoscope	Y20097353	1

Preparatory steps

1. Remove cylinder head cover (→ Page 79).
2. Remove injector (→ Page 81).

Positioning crankshaft at BDC

1. Using barring gear, turn crankshaft until crankshaft journal of the cylinder to be inspected has reached BDC.
2. Insert endoscope into cylinder liner through injector seat.

Endoscopic examination of cylinder liner

Findings	Action
• Thin carbon coating on circumference of carbon scraper ring • Slight localized additive deposits at top edge • Localized smooth areas on bottom edge • Carbon deposits on circumference in clearance between top piston ring and bottom edge of carbon scraper ring • First signs of marks left by top piston ring • Bright mark on entire circumference • Consistent honing pattern without objections • First signs of marks left by lower cooling bores • Running pattern seems darker	No action required
• Dark areas with even or varying degrees of discoloration • Beginning and end of the discoloration are not sharply defined and do not cover the entire stroke area • Dark areas in the upper section of the cooling bore, remaining circumference without objections • Piston rings without objections	Further endoscopic examination required as part of maintenance work
• On the entire circumference, apart from light areas of discoloration (that do not impair operation) clearly darker stripes that start at the top piston ring • Heat discoloration in the direction of stroke and honing pattern damage • Heat discoloration of piston rings	Cylinder liner must be replaced; Service must be contacted

1. Compile endoscopy report using the table.
2. Use technical terms for description of the liner surface (→ Page 71).
3. Depending on findings:
   - do not take any action or
   - carry out a further endoscopic examination as part of maintenance work or
   - contact Service; cylinder liner must be replaced.

TIM-ID: 0000000015 - 013

Final steps

1. Install injector (→ Page 81).
2. Install cylinder head cover (→ Page 79).

TIM-ID: 0000000015 - 013

7.3.2 Cylinder liner – Instructions and comments on endoscopic and visual examination

Terms used for endoscopic examination

Use the terms listed below to describe the condition of the cylinder-liner surface in the endoscopic examination report.

Findings	Measure
Minor dirt scores	Minor dirt scores can occur during the assembly of a new engine (honing products, particles, broken-off burrs). Removed cylinders clearly show such scoring on the running surface under endoscope magnification. Cannot be felt with the fingernail. Findings not critical.
Single scores	Clearly visible scores caused by hard particles. They usually start in the TDC area and cross through the hone pattern in the direction of stroke. Findings not critical.
Scored area	These areas consist of scores of different length and depth next to one another. In most cases, they are found at the 6-o'clock and 12-o'clock positions (inlet/exhaust) along the transverse engine axis. Findings not critical.
Smoothened area	Smoothened areas are on the running surface but almost the whole honing pattern is still visible. Smoothened areas appear brighter and more brilliant than the surrounding running surface. Findings not critical.
Bright area	Bright areas are on the running surface and show local removal of the honing pattern. Grooves from honing process are not visible any more.
Discoloration	This is caused by oxidation (surface discoloration through oil or fuel) and temperature differences around the liner. It appears rather darker within the honed structure in contrast to the bright metallic running surface. The honing pattern is undisturbed. Discolorations extend in stroke direction and may be interrupted. Findings not critical.
Corrosion fields / spots	Corrosion fields / spots result from water (condensed water) with the valves in the overlap (open) position. They are clearly visible due to the dark color of the honing groove bottom. This corrosion is not critical unless there is corrosion pitting.
Black lines	Black lines are a step towards heat discoloration. They are visible as a clear discoloration from TDC to BDC in the running surface and the start of localized damage to the honing pattern. Cylinder liners with a large number of black lines around the running surface have limited service life and should be replaced.

TIM-ID: 0000000014 - 013

Findings	Measure
Burn mark	This is caused by a malfunction in the liner / ring tribosystem. Usually they run over the whole ring-travel area (TDC/BDC), starting at the first TDC-ring and becoming more visible from the second TDC-ring 2 onwards and less pronounced from TDC-ring 1. The honing pattern is usually no longer visible and displays a clearly defined (straight) edge to the undisturbed surface. The damaged surface is usually discolored. The circumferential length varies. Liners with burn marks, or heat discoloration, starting in TDC ring 1 have to be replaced.
Seizure marks, scuffing	Irregular circumference lengths and depths. Can be caused either by the piston skirt or the piston crown. Material deposits on the liner (smear), heavy discoloration. Severe, visible scoring. Replace liner.

Evaluation of findings and further measures

The findings in the start phase of oxidation discoloration and heat discoloration are similar. A thorough investigation and compliance with the above evaluation criteria allow an unambiguous evaluation. To avoid unnecessary disassembly work, it is recommended that another inspection be carried out after further operation of the engine.

TIM-ID: 0000000014 - 013

7.4 Crankcase Breather

7.4.1 Crankcase breather – Cleaning oil pre-separator element

Preconditions

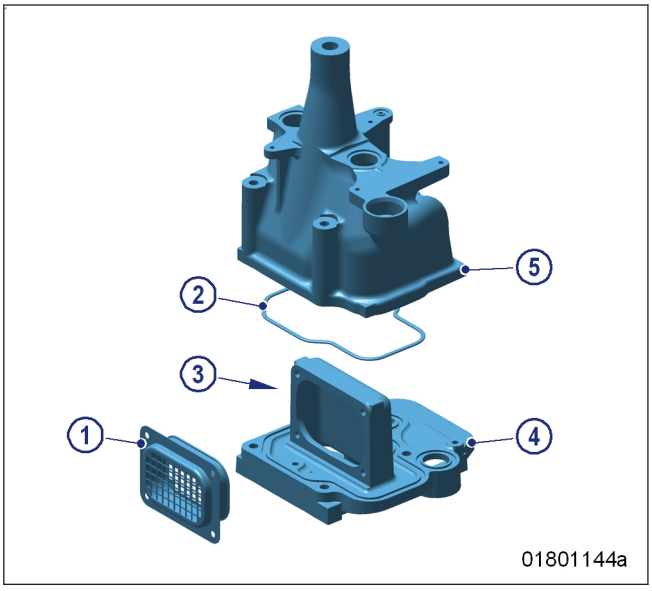
☑ Engine is stopped and starting disabled.

WARNING	
	Fuels are combustible. **Risk of fire and explosion!** • Avoid open flames, electrical sparks and ignition sources. • Do not smoke.

WARNING	
	Compressed air **Risk of injury!** • Do not direct compressed-air jet at persons. • Wear protective goggles / safety mask and ear protectors.

Crankcase breather – Cleaning oil pre-separator element

1. Remove cover (5) from housing (4).
2. Take off oil pre-separator element (1), gasket (3) and O-ring (2).
3. Wash oil pre-separator element (1) and housing (4) in fuel and blow out with compressed air.
4. Moisten oil pre-separator element (1) with engine oil.
5. Position oil pre-separator element (1) with new gasket (3) and O-ring (2) on housing (4) and install cover (5).
6. Clean further oil pre-separator elements in the same way.



TIM-ID: 0000011545 - 004

7.4.2 Kurbelgehäuseentlüftung – Ölabscheidereinsatz ersetzen, Membrane prüfen und ersetzen

Preconditions

☑ Motor abgestellt und gegen Starten gesichert.

Special tools, Material, Spare parts

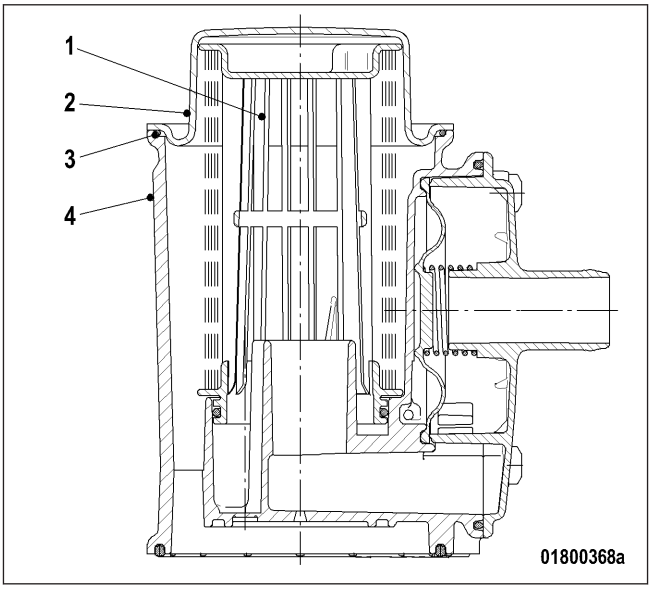
Designation / Use	Part No.	Qty.
Drehmomentschlüssel, 6-50 Nm	F30027336	1
Einsteckknarre	F30027340	1
Filtereinsatz	(→ Spare Parts Catalog)	
Membrane	(→ Spare Parts Catalog)	
Runddichtring	(→ Spare Parts Catalog)	

WARNING

Heißes Öl.
Öl kann gesundheitsschädliche Verbrennungsrückstände enthalten.
Verbrennungs- und Vergiftungsgefahr!
- Schutzkleidung, Schutzhandschuhe und Schutzbrille/Gesichtsschutz tragen.
- Hautkontakt vermeiden.
- Öldämpfe nicht einatmen.

Ölabscheidereinsatz ersetzen

1. Verschlussdeckel (2) mit Runddichtring (3) abbauen.
2. Filtereinsatz (1) aus dem Gehäuse (4) herausnehmen.
3. Neuen Filtereinsatz lagerichtig in Gehäuse (4) einsetzen und Verschlussdeckel (2) mit neuen Runddichtring anbauen.



4. Schrauben des Verschlussdeckels (2) auf vorgeschriebenes Anziehdrehmoment anziehen.

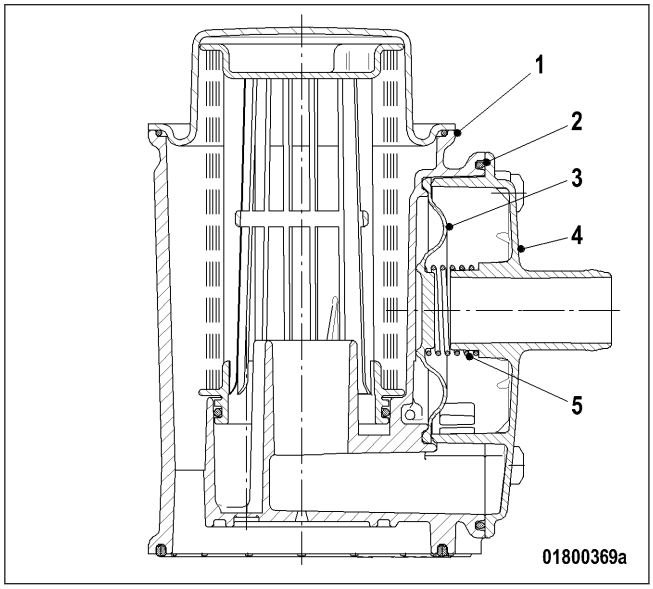
Name	Size	Type	Lubricant	Value/Standard
Schraube		Tightening torque		6 Nm + 2 Nm

5. Weitere Ölabscheidereinsätze in gleicher Weise ersetzen.

TIM-ID: 0000027984 - 003

Membrane prüfen

1. Deckel (4) abbauen.
2. Feder (5), Dichtung (2) und Membrane (3) abnehmen.
3. Membrane (3) auf Beschädigung prüfen.
4. Ist Membrane beschädigt, Membrane ersetzen.
5. Membrane (3) an Gehäuse (1) anbauen.
6. Neue Dichtung (2) und Feder (5) zusammen mit Deckel (4) anbauen.



7. Schrauben des Verschlussdeckels (4) auf vorgeschriebenes Anziehdrehmoment anziehen.

Name	Size	Type	Lubricant	Value/Standard
Schraube		Tightening torque		6 Nm + 2 Nm

8. Membranen in weiteren Ölabscheidern in gleicher Weise prüfen.

TIM-ID: 0000027984 - 003

7.5 Valve Drive

7.5.1 Valve clearance – Check and adjustment

Preconditions

☑ Engine is stopped and starting disabled.

☑ Engine coolant temperature is max. 40 °C.

☑ Valves are closed.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Feeler gauge	Y4345893	1
Barring tool	F6783914	1
Ratchet	F30006212	1
Double box wrench	F30002800	1
Angular screw driver	F30002816	1
Socket wrench	F30030450	1
Torque wrench, 10-60 Nm	F30510423	1

Preparatory steps

1. Remove air filter (→ Page 94).
2. Remove cylinder head cover (→ Page 79).

Positioning A1 piston at TDC

1. Remove cable from sensor B13 (→ Page 28).
2. Remove sensor B13.
3. Using ratchet and barring tool, rotate crankshaft in engine direction of rotation until the marking on the flywheel is aligned with the center of the sensor seat.

Checking valve clearance at two crankshaft positions

1. Check TDC position of piston in cylinder A1:
   - If the rocker arms are unloaded on cylinder A1, the piston is in firing TDC.
   - If the rocker arms are loaded on cylinder A1, the piston is in overlap TDC.
2. Check valve clearance with cold engine:
   - Inlet (E) = 0.3 mm;
   - Exhaust (A) = 0.4 mm.
3. Check all valve clearances at two crankshaft positions (firing TDC and overlap TDC) according to the table below.

8V2000										
Position	Cylinder	1	2	3	4	5	6	7	8	9
Firing TDC in cylinder A1	Bank A	E A	- A	E -	- A					
	Bank B	E -	E -	- -	- A					
Overlap TDC in cylinder A1	Bank A	- -	E -	- A	E -					
	Bank B	- A	- A	E A	E -					
“E” = inlet valve clearance adjustment permitted, “A” = exhaust valve clearance adjustment permitted										

TIM-ID: 0000004363 - 003

10V2000										
Position	Cylinder	1	2	3	4	5	6	7	8	9
Firing TDC in cylinder A1	Bank A	E A	- -	- -	- A	E -				
	Bank B	E -	- -	- A	E A	E -				
Overlap TDC in cylinder A1	Bank A	- -	E A	E A	E -	- A				
	Bank B	- A	E A	E -	- -	- A				
“E” = inlet valve clearance adjustment permitted, “A” = exhaust valve clearance adjustment permitted										
12V2000										
Position	Cylinder	1	2	3	4	5	6	7	8	9
Firing TDC in cylinder A1	Bank A	E A	E -	- A	E -	- A	- -			
	Bank B	E -	- -	- A	E -	E A	- A			
Overlap TDC in cylinder A1	Bank A	- -	- A	E -	- A	E -	E A			
	Bank B	- A	E A	E -	- A	- -	E -			
“E” = inlet valve clearance adjustment permitted, “A” = exhaust valve clearance adjustment permitted										
16V2000										
Position	Cylinder	1	2	3	4	5	6	7	8	9
Firing TDC in cylinder A1	Bank A	E A	- A	- A	E -	- A	E -	- -	- -	
	Bank B	E -	- A	- -	E -	E A	E -	E A	- A	
Overlap TDC in cylinder A1	Bank A	- -	E -	E -	- A	E -	- A	E A	E A	
	Bank B	- A	E -	E A	- A	- -	- A	- -	E -	
“E” = inlet valve clearance adjustment permitted, “A” = exhaust valve clearance adjustment permitted										
18V2000										
Position	Cylinder	1	2	3	4	5	6	7	8	9
Firing TDC in cylinder A1	Bank A	E A	E -	- A	E -	- A	- -	- A	- -	- -
	Bank B	- A	- A	- -	E A	- -	E A	E -	E A	E -
Overlap TDC in cylinder A1	Bank A	- -	- A	E -	- A	E -	E A	E -	E A	E A
	Bank B	E -	E -	E A	- -	E A	- -	- A	- -	- A
“E” = inlet valve clearance adjustment permitted, “A” = exhaust valve clearance adjustment permitted										

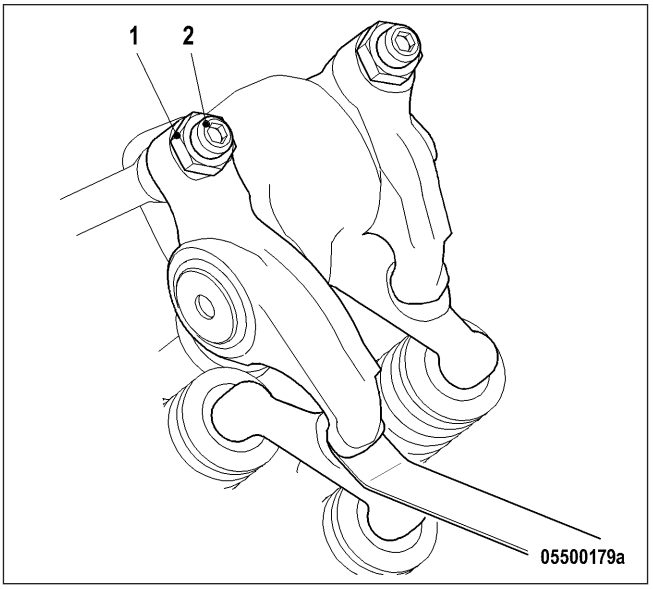
4. Use feeler gauge to determine the distance between valve bridge and rocker arm.
5. If the deviation from the reference value exceeds 0.1 mm, adjust valve clearance.

TIM-ID: 0000004363 - 003

Valve clearance adjustment

1. Loosen locknut (1) and unscrew adjusting screw (2) by a few threads.
2. Insert feeler gauge between valve bridge and rocker arm.
3. Readjust adjusting screw (2) so that the feeler gauge just passes through the gap.
4. Tighten locknut (1) with torque wrench to the prescribed tightening torque of 50 Nm while holding the adjusting screw (2) with screwdriver.
5. Insert feeler gauge between valve bridge and rocker arm to verify that the gauge just passes through the gap.

Result: If not, adjust valve clearance.



Final steps

1. Install sensor B13.
2. Connect cable to sensor B13.
3. Remove barring tool.
4. Install cylinder head cover (→ Page 79).
5. Install air filter (→ Page 94).

TIM-ID: 0000004363 - 003

7.5.2 Cylinder-head cover – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Centering device	F6783025	1
Gasket	(→ Spare Parts Catalog)	

Preparatory steps

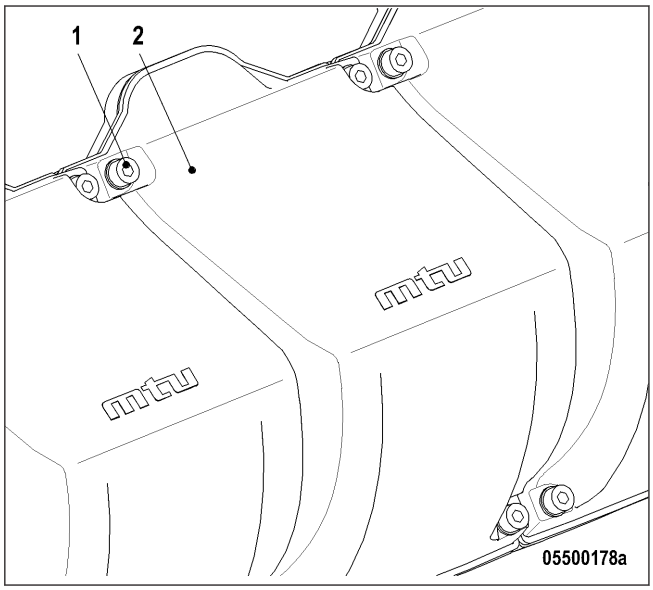
1. Remove air filter (→ Page 94).
2. Remove intake housing.

Cylinder-head cover – Removal and installation

1. Remove screws (1).
2. Remove cylinder-head cover (2) with gasket from cylinder head.
3. Clean mating faces.
4. Check condition of gasket of cylinder-head cover.

Result: Replace damaged gasket(s).

5. Center cylinder-head cover (2) with centering device.
6. Use torque wrench to tighten screws (1) to specified torque 20 Nm.



Final steps

1. Install air filter (→ Page 94).
2. Install intake housing.
3. Check cylinder-head covers for leaks.

TIM-ID: 0000004470 - 001

7.6 Injection Valve / Injector

7.6.1 Injector – Replacement

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Injector	(→ Spare Parts Catalog)	

Remove injector and install new one.

▶ (→ Page 81)

TIM-ID: 0000004642 - 002

7.6.2 Injector – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Socket wrench	0005896803/00	1
Puller	F6790629	1
Double box wrench	F30011450	1
Open end wrench bit	F30025897	1
Box wrench adapter	F30451199	1
Alignment device	F6790507	1
Grease (Kluthe Hakuform 30-10/Emulgier)	X00029933	1
Engine oil		

WARNING

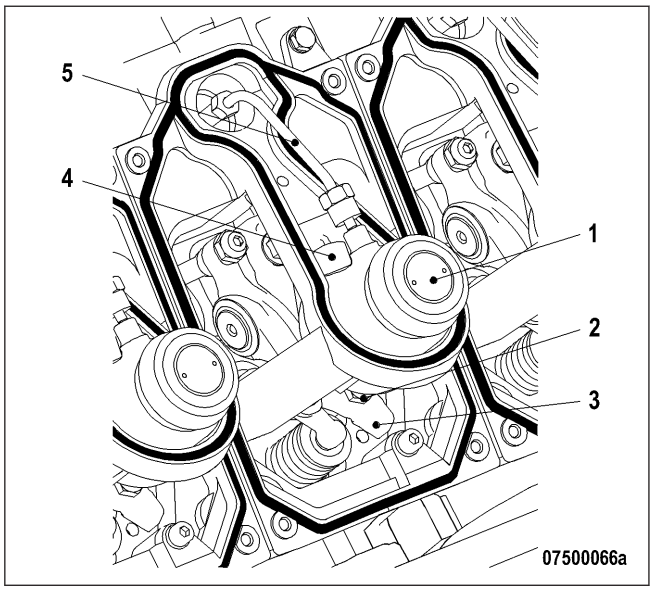
Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Preparatory steps

1. Close fuel supply to engine.
2. Remove cylinder head cover (→ Page 79).

Removing injector

1. Remove HP line (5) using socket wrench.
2. Disconnect injector cable (4).
3. Remove screw (2).
4. Take off hold-down clamp (3).
5. Remove injector (1) with puller.
6. Remove O-rings from injector.
7. Mask all connections and bores or seal with suitable plugs.



TIM-ID: 0000004650 - 002

Installing injector

1. Remove all plugs before installation.
2. Fit new O-rings onto injector and coat with grease.
3. Fit new sealing ring with grease on injector, ensuring correct installation position of sealing ring.
4. Clean sealing surface on cylinder head and protective sleeve.
5. Insert injector (1) in cylinder head, ensuring that it is correctly aligned with the HP line connection.
6. Fit hold-down clamp (3) in correct installation position, coat screw (2) with engine oil.
7. Screw in screw (2) and tighten by hand.
8. Coat thread and sealing cone of HP line (5) and injector (1) with engine oil.
9. Align injector (1) and HP line (5) with alignment device.
10. Connect HP line (5) to HP accumulator and tighten by hand.
11. Connect HP line (5) to injector (1) and tighten by hand.
12. Tighten screw of hold-down clamp (3) with a box wrench adapter and a torque wrench to specified tightening torque.

Name	Size	Type	Lubricant	Value/Standard
Screw	M10 x 85	Tightening torque	(Engine oil)	40 Nm + 4 Nm

13. Use socket wrench and torque wrench to tighten HP line (5) to the specified torque.

Name	Size	Type	Lubricant	Value/Standard
HP fuel line		Tightening torque	(Engine oil)	30 Nm + 5 Nm

14. Attach cable (4).

Final steps

1. Install cylinder head cover (→ Page 79).
2. Open fuel supply to engine.

TIM-ID: 0000004650 - 002

7.7 Fuel System

7.7.1 Fuel system – Venting

Preconditions

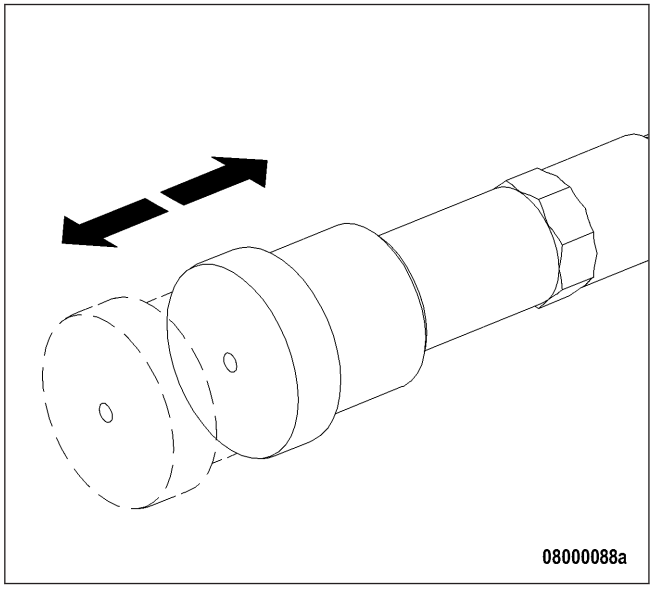
☑ Engine is stopped and starting disabled.

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Venting fuel system

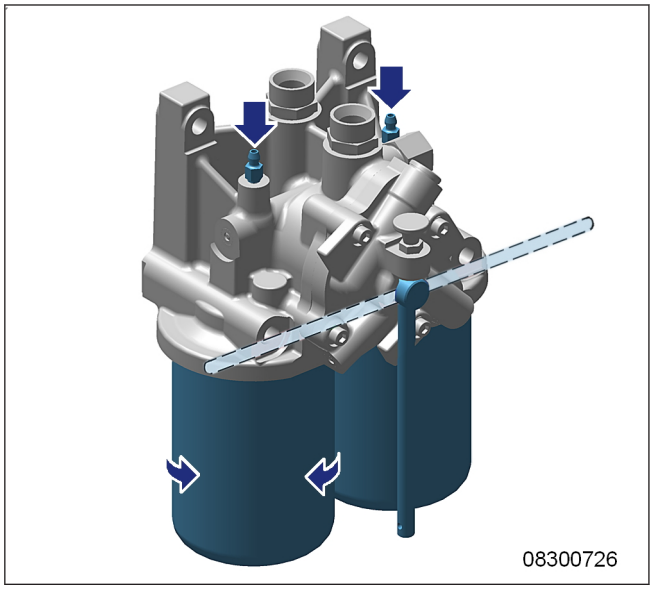
1. Unlock fuel priming pump, unscrew handle.



2. Open vent plugs on filter head.

Note: New version has two threaded vent plugs, old version has four threaded vent plugs.

3. Operate the pump with the handle until fuel without bubbles comes out of the vent plugs and the nipples.
4. Close vent plugs on filter head.
5. Operate the pump with the handle until fuel without bubbles comes out of the nipple.
6. Lock fuel priming pump, screw in handle.



TIM-ID: 0000004716 - 002

7.8 Fuel Filter

7.8.1 Fuel filter – Replacement

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1
Diesel fuel		
Easy-change filter	(→ Spare Parts Catalog)	

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

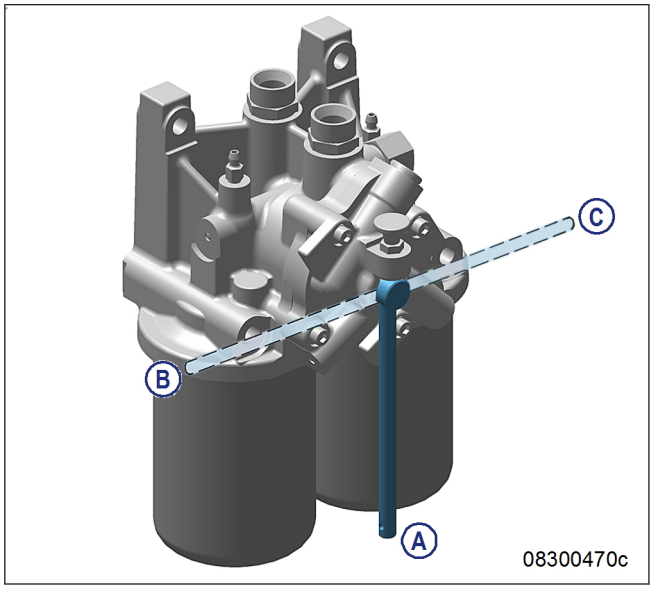
CAUTION

Damage to component.
Serious damage to plant!
- For filter replacement with the engine running, operate the engine at low engine load.
- The filter which is to be exchanged must be cut out for a brief period only.

TIM-ID: 0000004914 - 004

Easy-change fuel filter replacement with the engine stopped

1. Stop engine and disable engine start.
2. Cut out the filter to be replaced.
   - B Left filter cut out
   - C Right filter cut out
3. Remove cut-out easy-change filter using the oil filter wrench.
4. Clean sealing surface on filter head.
5. Check sealing ring of the new easy-change filter and coat it with fuel.
6. Fit SOLAS shield (→ Page 60).
7. Screw on easy-change filter and tighten by hand.
8. Set three-way cock to operating position (A) so that both filters are cut in (operating position).
9. Replace further fuel filters in the same way.
10. Vent fuel system (→ Page 83).

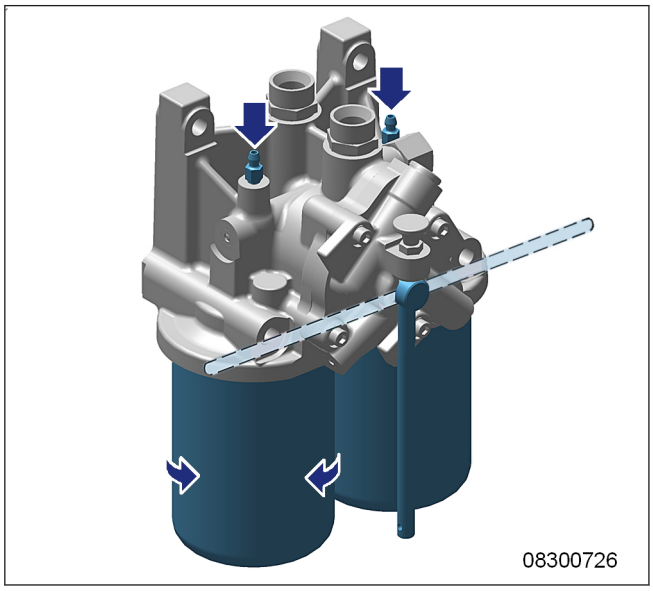


Easy-change fuel filter replacement with the engine running

1. Cut out the filter to be replaced.
2. Open the threaded vent plugs at the filter head of the cut-out filter and make sure that the fuel filter is not pressurized.

Note: New version has two threaded vent plugs, old version has four threaded vent plugs.

3. Close threaded vent plugs.
4. Remove cut-out easy-change filter using the oil filter wrench.
5. Clean sealing surface on filter head.
6. Check sealing ring of the new easy-change filter and coat it with fuel.
7. Fit SOLAS shield (→ Page 60).
8. Screw on easy-change filter and tighten by hand.
9. Set three-way cock to operating position (both filters cut in).
10. Replace further fuel filters in the same way.



TIM-ID: 0000004914 - 004

7.8.2 Fuel prefilter – Differential pressure check and adjustment of gauge

DANGER

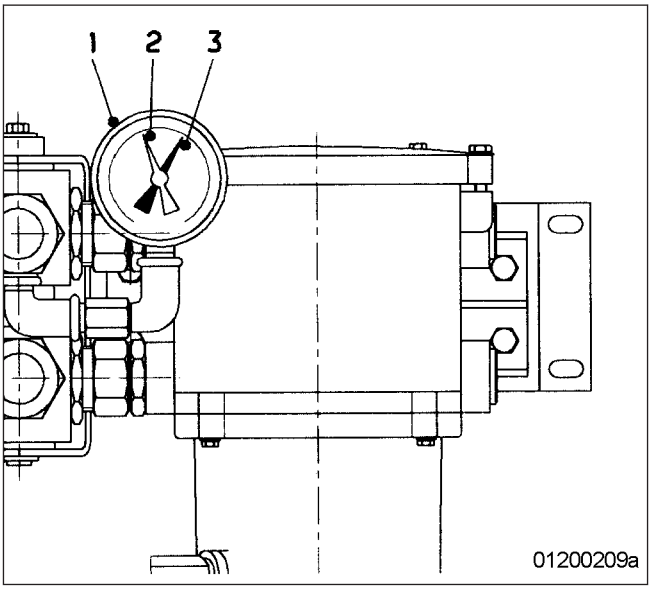
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Differential pressure gauge adjustment

1. When installing the new filter element: align adjustable pointer (2) with pressure-indicating pointer (3) of pressure gauge (1).
2. Verify that differential pressure is within the limit.



Fuel prefilter – Checking differential pressure

1. With the engine running at full load or rated power, read off pressure at gauge (1).
2. If differential pressure as indicated between position of adjustable pointer (2) and pressure indicator of pressure gauge (3) is ≥ 0.3 bar, flush filter element of the cut-in filter (→ Page 88).

TIM-ID: 0000004926 - 003

7.8.3 Fuel prefilter – Draining

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

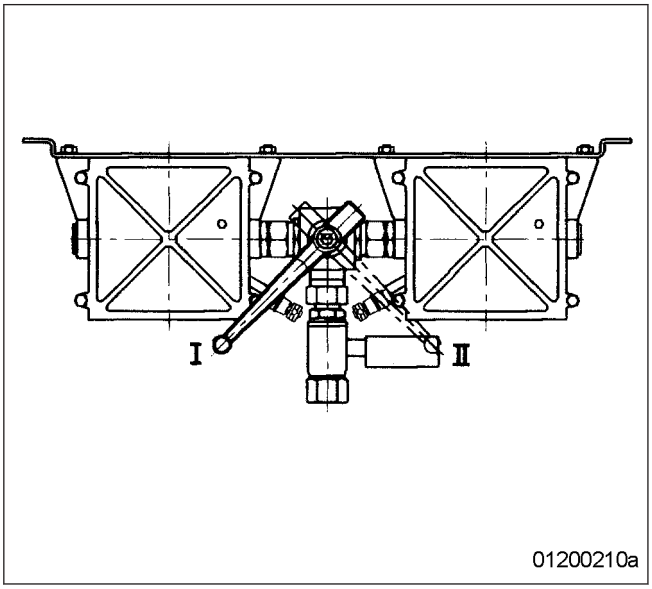
Designation / Use	Part No.	Qty.
Diesel fuel		
Seal	(→ Spare Parts Catalog)	

WARNING

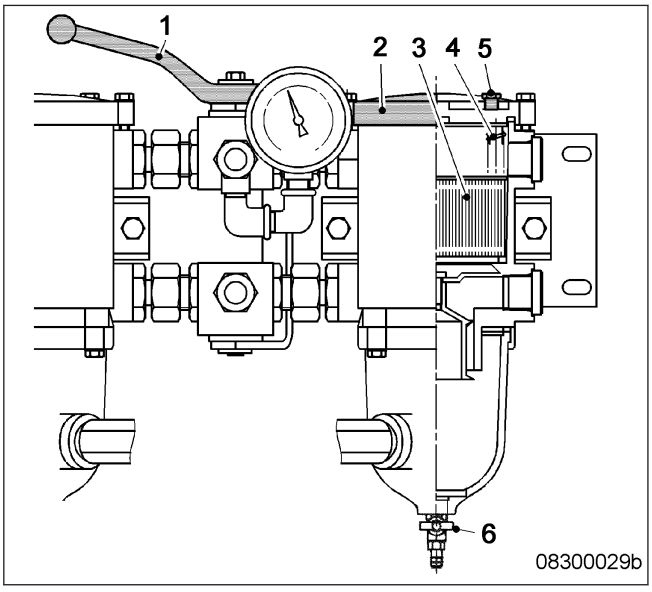
Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Fuel prefilter – Draining

1. Cut out the filter to be drained.
   I Left filter cut in
   II Right filter cut in



2. Open threaded vent plug (5) of the filter to be drained.
3. Unlock drain valve (6) by pressing toggle and open it.
4. Drain water and contaminants from the filter until pure fuel emerges.
5. Close drain valve (6).
6. Remove screws securing the cover and take off cover (2).
7. Fill filter housing with clean fuel.
8. Place new seal in cover (2).
9. Fit cover with gasket and secure it with screws.
10. Cut in the cut-out filter again.
11. Close threaded vent plug (5) when fuel emerges from system.



TIM-ID: 0000004933 - 004

7.8.4 Kraftstoffvorfilter spülen

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Kraftstoff		
Dichtung	(→ Spare Parts Catalog)	

DANGER

Drehende, bewegende Motorteile.
Schwere Körperverletzung – Lebensgefahr!
- Besondere Vorsicht am laufenden Motor.

WARNING

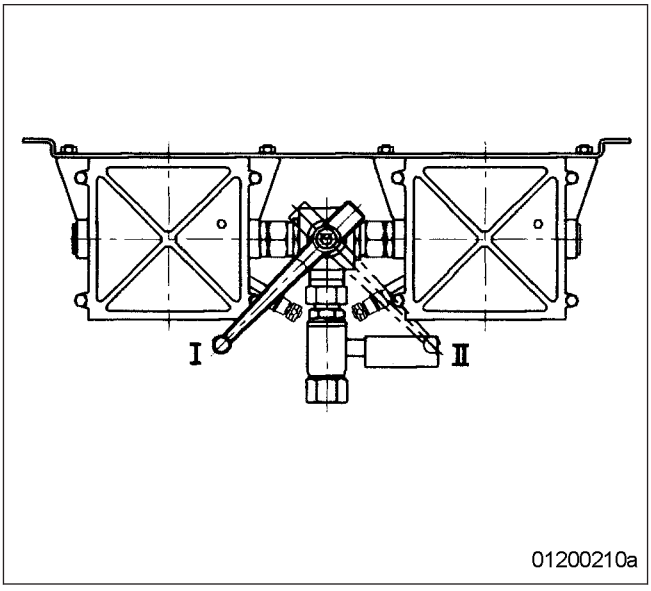
Kraftstoffe sind brennbar.
Brand- und Explosionsgefahr!
- Offenes Feuer, elektrischen Funken und Zündquellen vermeiden.
- Nicht rauchen.

WARNING

Motorgeräusch über 85 dB (A).
Gehörschaden!
- Gehörschutz tragen.

Kraftstoffvorfilter spülen

1. Verunreinigtes Filter abschalten.
   - I Linkes Filter zugeschaltet
   - II Rechtes Filter zugeschaltet

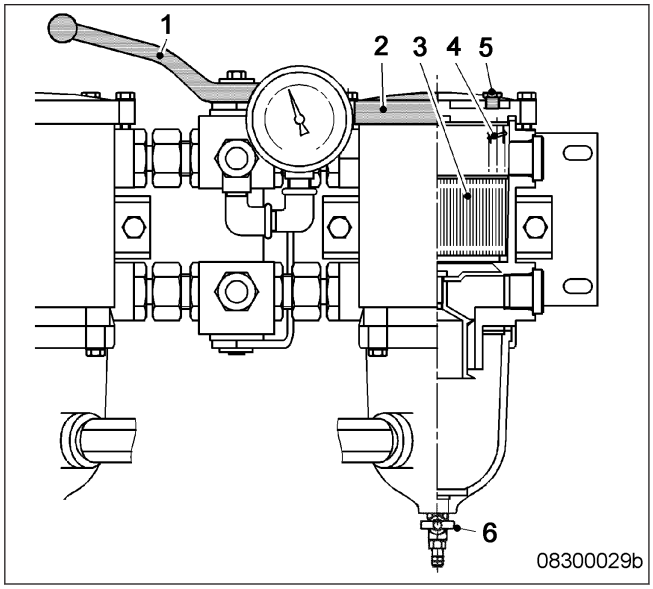


TIM-ID: 0000004937 - 015

2. Entlüftungsschraube (5) des zu spülenden Filters öffnen.
3. Ablassventil (6) durch Druck auf den Ventilknauf entriegeln, öffnen und Kraftstoff ablassen.

Result: Kraftstoff fließt von der Rein- zur Schmutzseite zurück und spült den Filterschmutz nach unten aus.

4. Entlüftungsschraube (5) und Ablassventil (6) schließen.



Kraftstoffvorfilter – Kraftstoff auffüllen

1. Motor abstellen (→ Page 50) und gegen Starten sichern.
2. Schrauben des Deckels abschrauben und Deckel (2) abnehmen.
3. Filtergehäuse mit sauberem Kraftstoff auffüllen.
4. Neue Dichtung in Deckel (2) einlegen.
5. Deckel mit Dichtung aufsetzen und Schrauben anziehen.
6. Differenzdruck prüfen (→ Page 86).

Result: Hat das Spülen keine Verbesserung des Differenzdrucks bewirkt, Kraftstoffvorfiltereinsatz ersetzen (→ Page 90).

TIM-ID: 0000004937 - 015

7.8.5 Fuel prefilter – Filter element replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

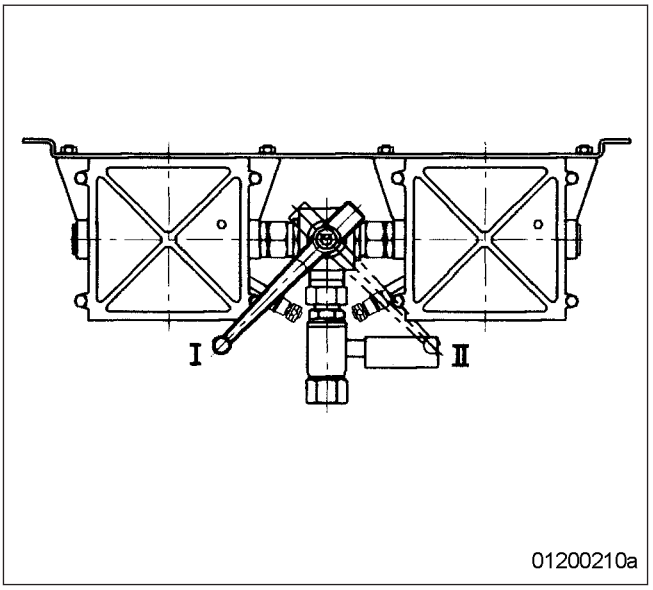
Designation / Use	Part No.	Qty.
Diesel fuel		
Filter element	(→ Spare Parts Catalog)	
Seal	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

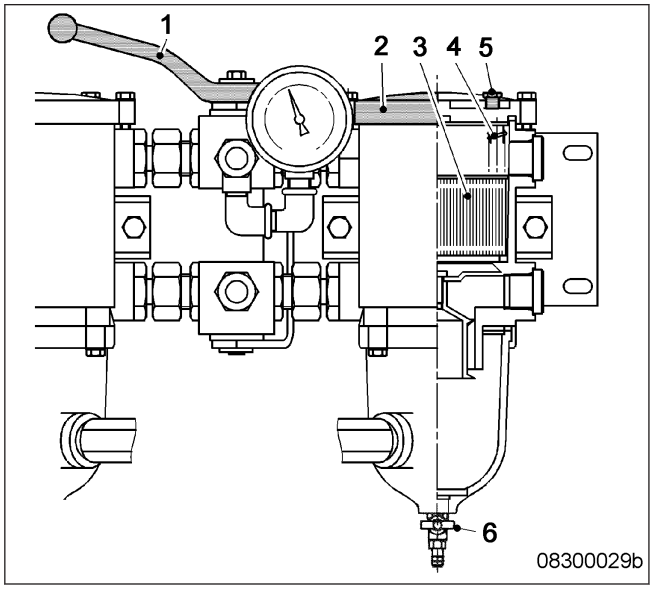
Replacing filter element

1. Cut out the contaminated filter.
   I Left filter cut in
   II Right filter cut in



TIM-ID: 0000004946 - 004

2. Open threaded vent plug (5) of contaminated filter.
3. Unlock drain valve (6) by pressing toggle and open it.
4. Drain water and contaminants from the filter.
5. Close drain valve (6).
6. Remove screws securing the cover and take off cover (2).
7. Remove spring housing (4) and filter element (3).
8. Insert new filter element (3) and spring housing (4).
9. Fill filter housing with clean fuel.
10. Place new seal in cover (2).
11. Fit cover with gasket and secure it with screws.
12. Cut in the cut-out filter again.
13. Close threaded vent plug (5) when fuel emerges.
14. Set adjustable pointer of differential pressure gauge (→ Page 86).



TIM-ID: 0000004946 - 004

7.9 Charge-Air Cooling

7.9.1 Intercooler – Checking condensate drain line for coolant discharge and obstruction

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

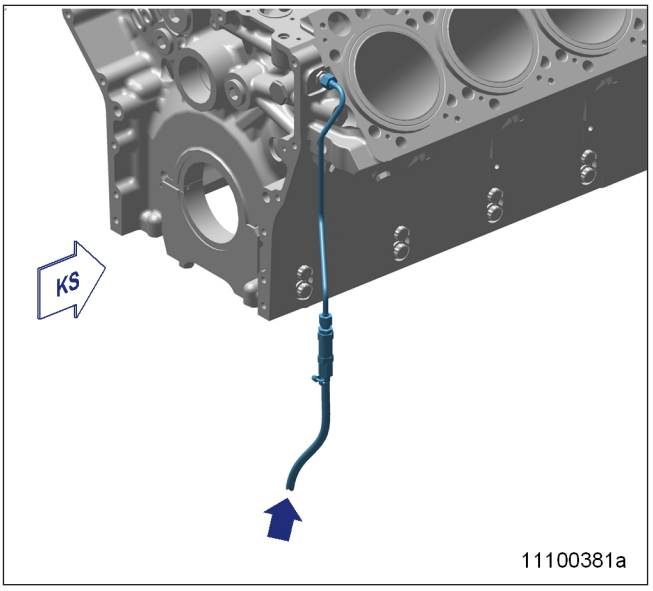
Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

WARNING

Compressed air
Risk of injury!
- Do not direct compressed-air jet at persons.
- Wear protective goggles / safety mask and ear protectors.

Intercooler – Checking condensate drain line for coolant discharge and obstruction

1. Check drain line for water discharge and obstruction when the engine is running idle.
2. If no air emerges, remove condensate drain line and blow out with compressed air.
3. Replace obstructed drain line by new one.
4. Install condensate drain line.
5. If a large amount of coolant is continuously discharged, the intercooler is leaking. Contact Service.



Emergency measures prior to engine start with a leaking intercooler

1. Remove injectors (→ Page 80).
2. Bar engine manually (→ Page 67).
3. Bar engine with starting system to blow out combustion chambers (→ Page 68).
4. Install injectors (→ Page 81).

TIM-ID: 0000027574 - 003

7.10 Air Filter

7.10.1 Luftfilter ersetzen

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Luftfilter	(→ Spare Parts Catalog)	

Luftfilter ersetzen

1. Alten Luftfilter aus- und neuen Luftfilter einbauen (→ Page 94).
2. Signalring des Unterdruckanzeigers zurücksetzen (→ Page 95).

TIM-ID: 0000005447 - 009

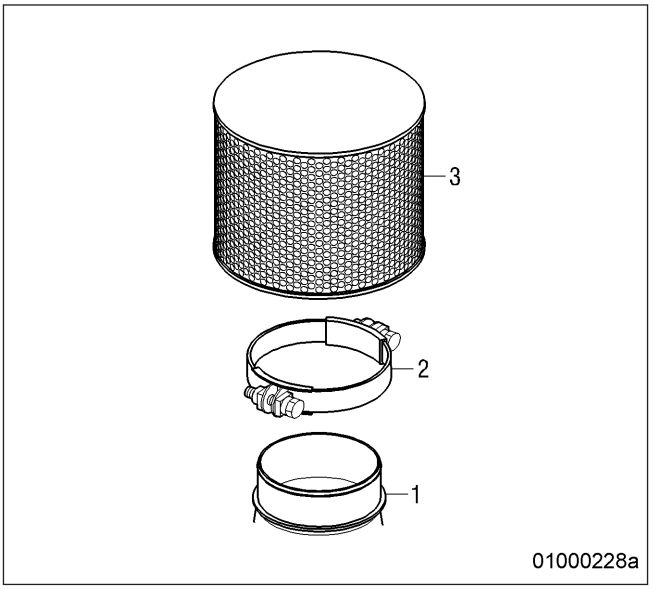
7.10.2 Air filter – Removal and installation

Preconditions

☑ Engine is stopped and starting disabled.

Air filter – Removal and installation

1. Release clamp (2).
2. Remove air filter (3) and clamp (2) from flange of intake housing (1).
3. Verify that there are no objects in the flange of the intake housing (1) and clean it.
4. Place new air filter (3) with clamp (2) onto intake housing (1).
5. Tighten clamp (2).



TIM-ID: 0000005457 - 005

7.11 Air Intake

7.11.1 Contamination indicator – Signal ring position check

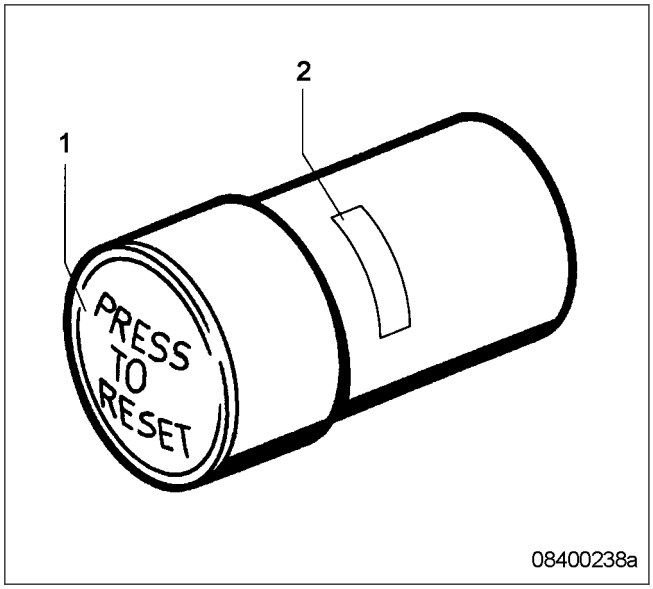
Preconditions

☑ Engine is stopped and starting disabled.

Checking signal ring position

1. If the signal ring is completely visible in the control window (2), replace air filter (→ Page 93).
2. After installation of new filter, press reset button (1).

Result: Engaged piston with signal ring moves back to initial position.



TIM-ID: 0000005484 - 006

7.12 Starting Equipment

7.12.1 Starter – Condition check

Preconditions

☑ Engine is stopped and starting disabled.

Starter – Condition check

1. Check securing screws of starter for secure seating and tighten if required.
2. Check wiring (→ Page 126).

TIM-ID: 0000000905 - 015

7.13 Lube Oil System, Lube Oil Circuit

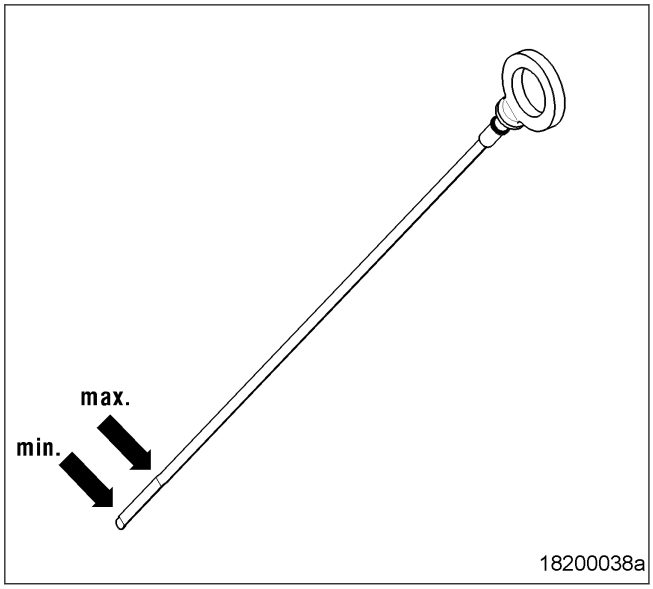
7.13.1 Engine oil – Level check

Preconditions

☑ Engine is stopped and starting disabled.

Oil level check prior to engine start

1. Withdraw oil dipstick from guide tube and wipe it.
2. Insert oil dipstick into guide tube up to the stop, withdraw after approx. 10 seconds and check oil level.
3. Oil level must be between "min." and "max." marks.
4. Top up to "max." if required (→ Page 98).
5. Insert oil dipstick into guide tube up to the stop.



Oil level check after the engine is stopped

1. 5 minutes after stopping the engine, remove oil dipstick from the guide tube and wipe it.
2. Insert oil dipstick into guide tube up to the stop, withdraw after approx. 10 seconds and check oil level.
3. Oil level must be between “min.” and "max." marks.
4. Top up to "max." if required (→ Page 98).
5. Insert oil dipstick into guide tube up to the stop.

TIM-ID: 0000000032 - 002

7.13.2 Engine oil – Change

Preconditions

☑ Engine is stopped and starting disabled.

☑ Engine is at operating temperature.

☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine oil		

WARNING

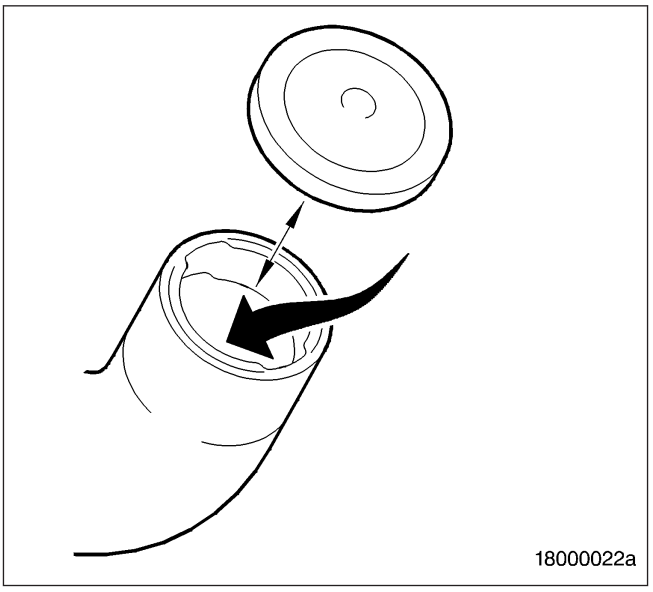
Hot oil.
Oil can contain combustion residues which are harmful to health.
Risk of injury and poisoning!
- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

Version with extraction equipment: Extracting engine oil

1. Position a suitable container to drain the engine oil into.
2. Extract all engine oil from oil pan using the extraction equipment.

Filling with new engine oil

1. Determine amount of engine oil required for oil change (→ Product Summary - Technical Data).
2. Open cover on filler neck.
3. Fill engine oil through filler neck up to “max.” mark on oil dipstick.
4. Close cover on filler neck.
5. Check engine oil level (→ Page 97).
6. After oil change, bar engine with starting system.



TIM-ID: 0000024903 - 001

7.14 Oil Filtration / Cooling

7.14.1 Engine oil filter – Replacement

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1
Engine oil		
Oil filter	(→ Spare Parts Catalog)	
Plastic ring	(→ Spare Parts Catalog)	

DANGER

Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

WARNING

Hot oil.
Oil can contain combustion residues which are harmful to health.
Risk of injury and poisoning!
- Wear protective clothing, gloves, and goggles / safety mask.
- Avoid contact with skin.
- Do not inhale oil vapor.

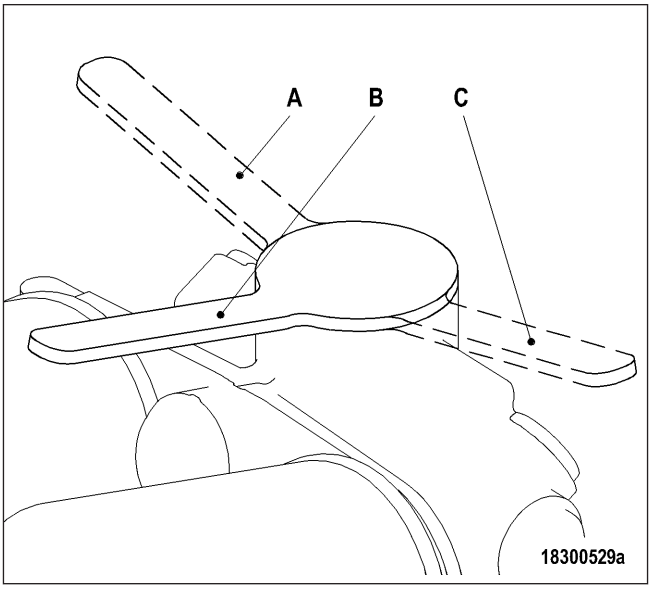
CAUTION

Damage to component.
Serious damage to plant!
- For filter replacement with the engine running, operate the engine at low engine load.
- The filter which is to be exchanged must be cut out for a brief period only.

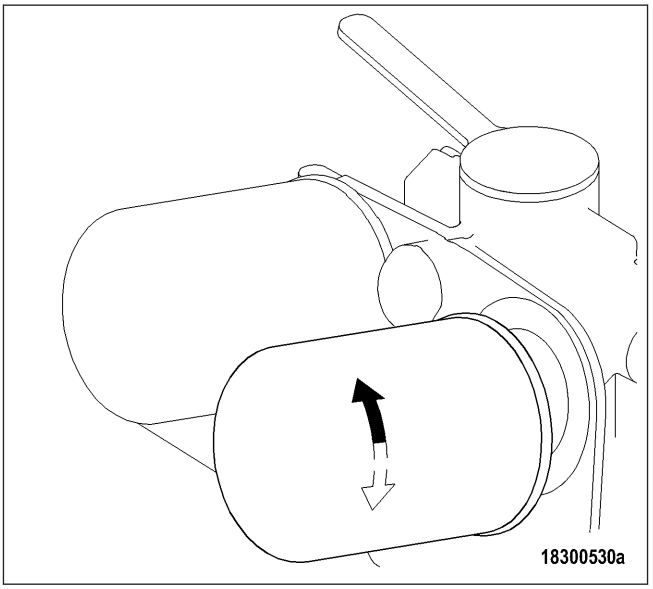
TIM-ID: 0000006385 - 005

Oil filter replacement with the engine stopped

1. Stop engine (→ Page 50) and disable engine start.
2. Cut out the filter to be replaced.
   - A Right filter cut out
   - B Both filters cut in (normal operating position)
   - C Left filter cut out



3. Remove cut-out oil filter using the oil filter wrench.
4. Clean sealing surface on connecting piece.
5. Check condition of new oil filter sealing ring and coat it with oil.
6. Fit SOLAS shield (→ Page 60).
7. Screw on and tighten new engine oil filter by hand.
8. Replace other oil filters in the same way.
9. Switch filter to normal position.
10. After each oil change and filter replacement, crank engine with starting system (→ Page 68).
11. Check oil level (→ Page 97).



Oil filter replacement with the engine running

1. Reduce engine speed to <1100 rpm.
2. Remove cut-out oil filter using the oil filter wrench.
3. Clean sealing surface on connecting piece.
4. Check condition of new oil filter sealing ring and coat it with oil.
5. Fit SOLAS shield (→ Page 60).
6. Screw on and tighten new engine oil filter by hand.
7. Replace other oil filters in the same way.
8. Switch filter to normal position.
9. Check oil level (→ Page 97).

TIM-ID: 0000006365 - 005

7.14.2 Ölzentrifuge reinigen und Einlegemanschette ersetzen

Preconditions

☑ Motor ist abgestellt und gegen Starten gesichert.

Special tools, Material, Spare parts

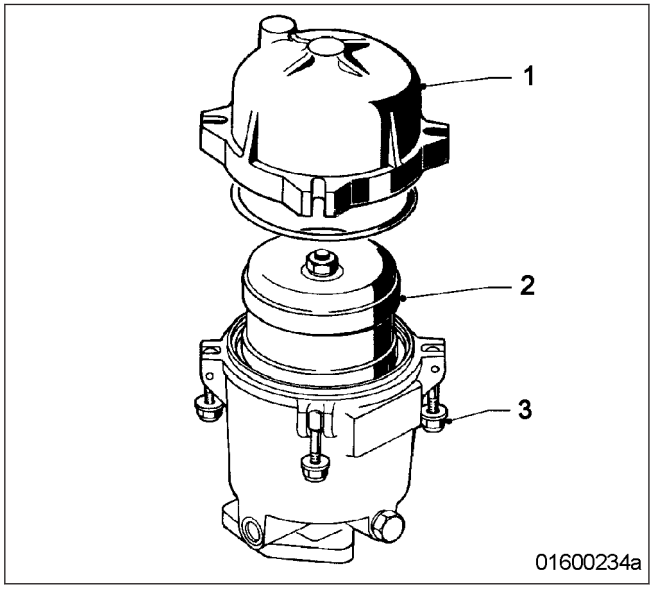
Designation / Use	Part No.	Qty.
Bandschlüssel	F30379104	1
Kaltreiniger (Hakutex 50)	50622	1
Einlegemanschette	(→ Spare Parts Catalog)	
Runddichtring	(→ Spare Parts Catalog)	
Runddichtring	(→ Spare Parts Catalog)	

WARNING

Druckluft.
Verletzungsgefahr!
- Druckluftstrahl nie auf Personen richten.
- Schutzbrille/Gesichtsschutz und Gehörschutz tragen.

Ölzentrifuge – Rotor ausbauen

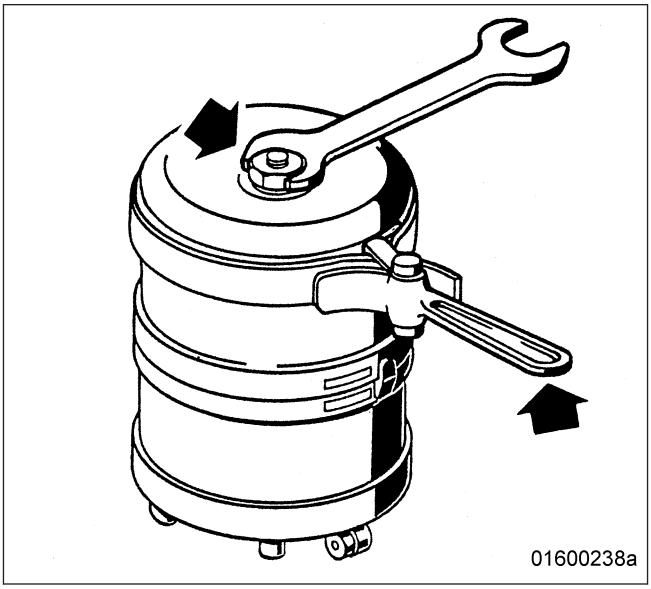
1. Muttern (3) lösen.
2. Gehäusedeckel (1) abbauen.
3. Kompletten Rotor (2) aus dem Gehäuse nehmen.



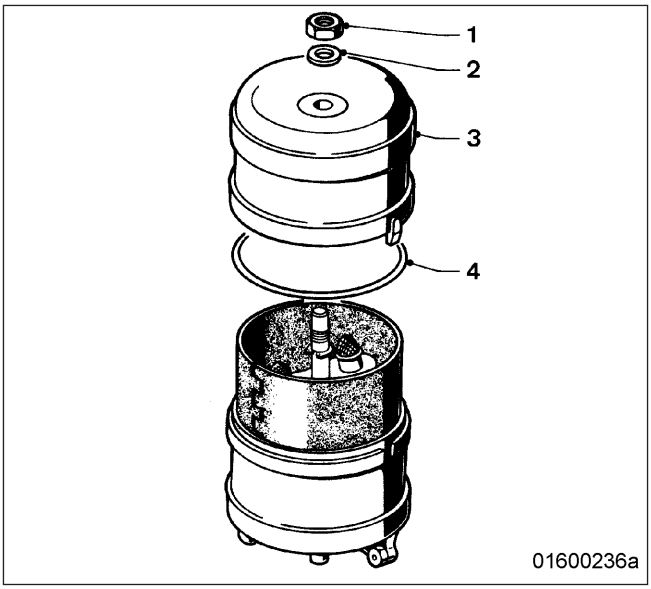
TIM-ID: 0000006418 - 002

Ölzentrifuge reinigen und Einlegemanschette ersetzen

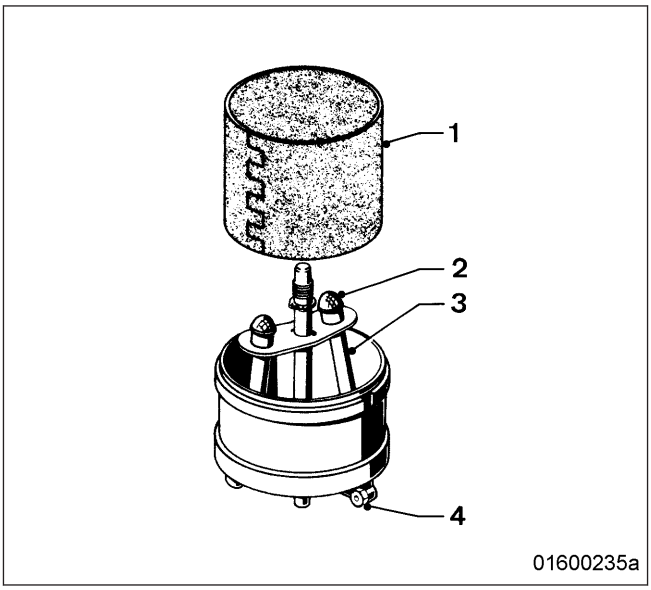
1. Rotor mit einem Bandschlüssel festhalten und Mutter abschrauben.



2. Mutter (1) , Scheibe (2), Rotoroberteil (3) und Runddichtring (4) abnehmen.

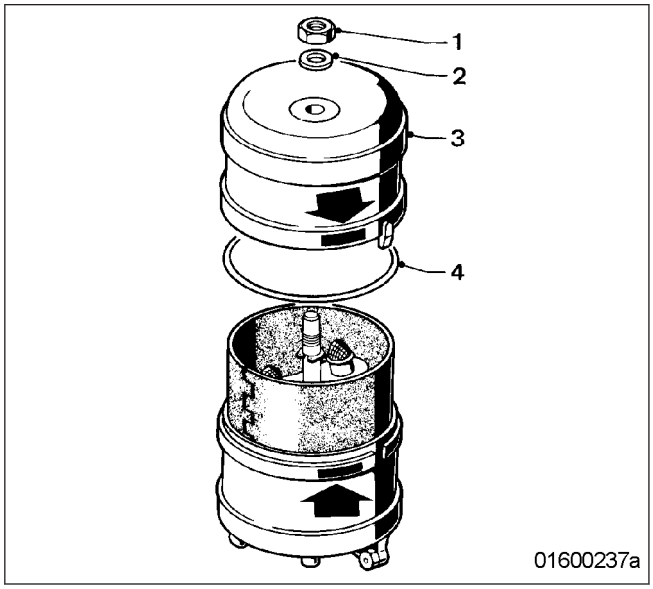


3. Einlegemanschette (1) herausnehmen.
4. Die Schichtdicke der Ölrückstände messen.
5. Überschreitet die max. Schichtdicke der Ölrückstände 25 mm, Wartungsintervall verkürzen.
6. Rotorteile reinigen und Siebe (2) herausnehmen.
7. Standrohre (3) und Düsen (4) mit Reinigungsmittel auswaschen und mit Druckluft ausblasen.
8. Neue Einlegemanschette so einlegen, dass Einlegemanschette mit glatter Seite zur Rotorkappe zeigt.



TIM-ID: 0000006418 - 002

9. Neuen Runddichtring (4) auflegen.
10. Rotoroberteil (3) aufsetzen, Kennzeichnung beachten.
11. Scheibe (2) auflegen.



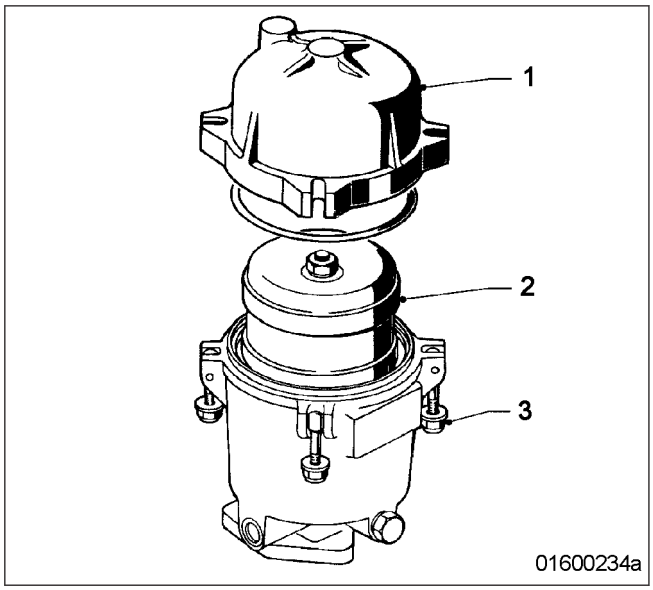
12. Rotor Neu mit Bandschlüssel festhalten und Mutter (1) mit Drehmomentschlüssel auf vorgeschriebenes Anziehdrehmoment anziehen.

Name	Size	Type	Lubricant	Value/Standard
Mutter	M18 x 1,5	Tightening torque		10 Nm

13. Rotor Alt mit Bandschlüssel festhalten und Mutter (1) mit Drehmomentschlüssel auf vorgeschriebenes Anziehdrehmoment anziehen.

Name	Size	Type	Lubricant	Value/Standard
Mutter	M16 x 1,5	Tightening torque		40 Nm bis 50 Nm

14. Kompletten Rotor (2) in das Gehäuse einsetzen und auf leichten Lauf prüfen.
15. Gehäusedeckel (1) mit neuen Runddichtring aufsetzen, Kennzeichnung beachten.
16. Muttern (3) gleichmäßig und diagonal anziehen.

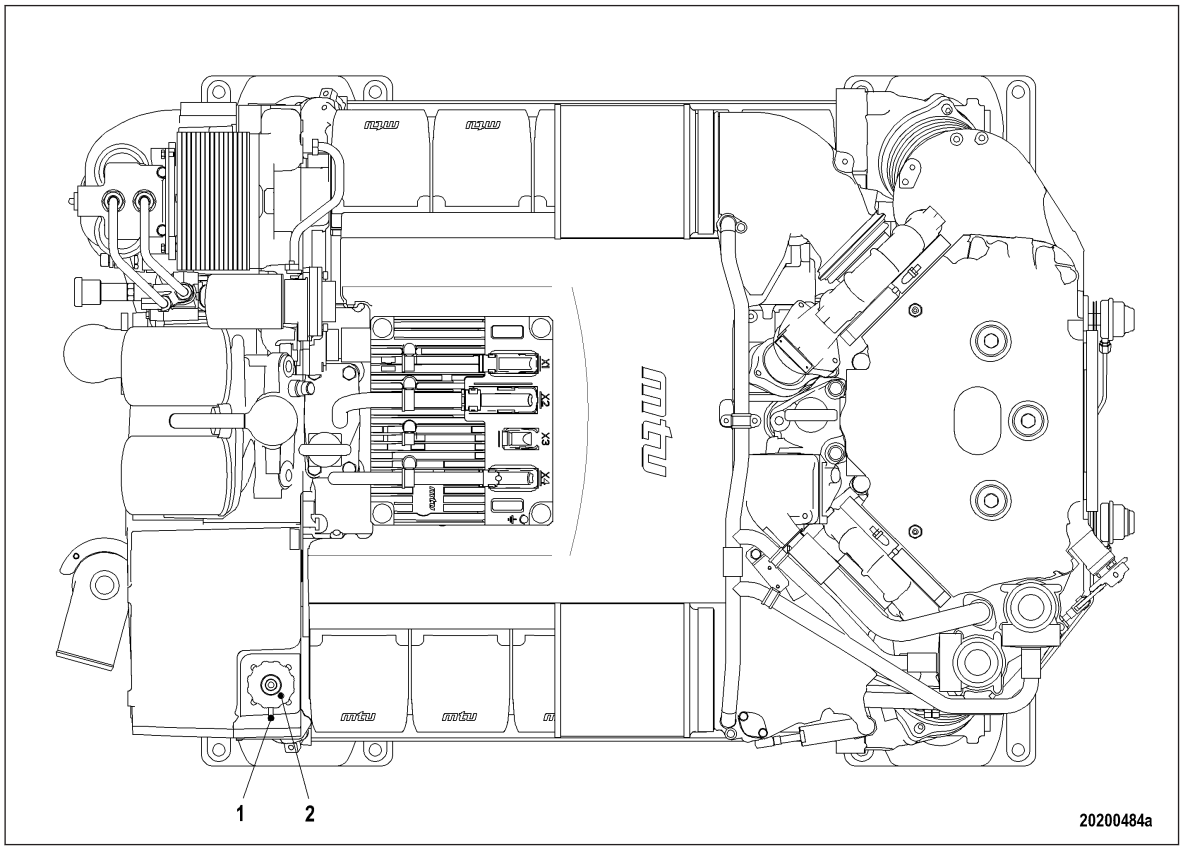


TIM-ID: 0000006418 - 002

7.15 Coolant Circuit, General, High-Temperature Circuit

7.15.1 Drain and venting points

8 V, 10 V

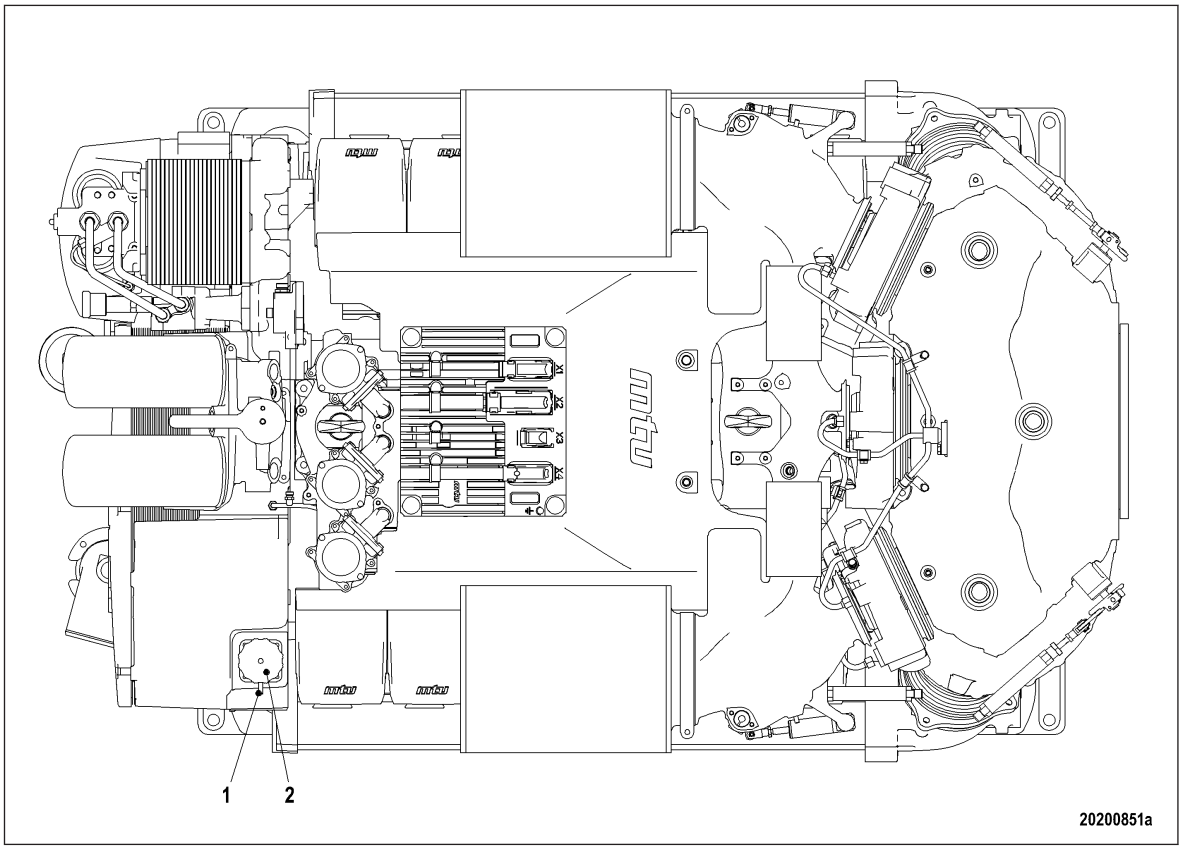


1 Overflow line, expansion tank

2 Filler neck

TIM-ID: 0000006696 - 001

12 V, 16 V

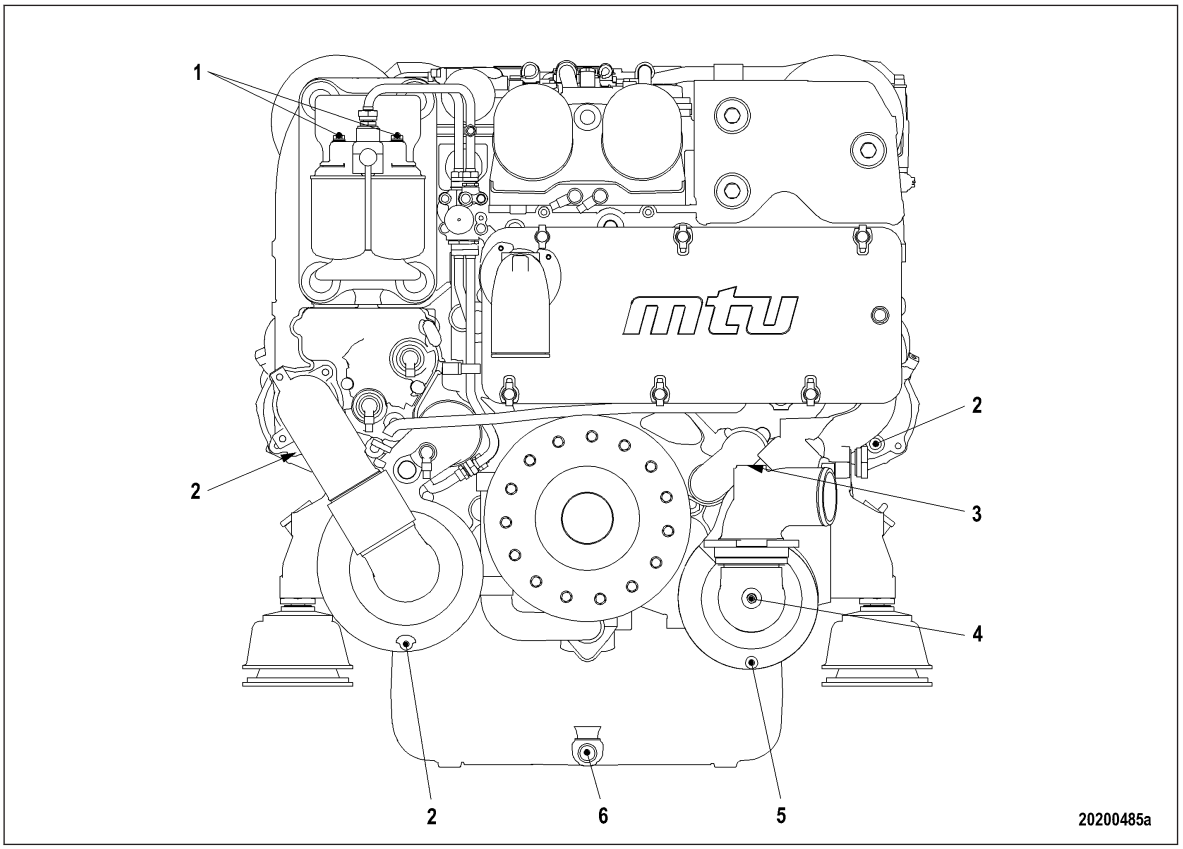


1 Overflow line, expansion tank

2 Filler neck

TIM-ID: 0000006696 - 001

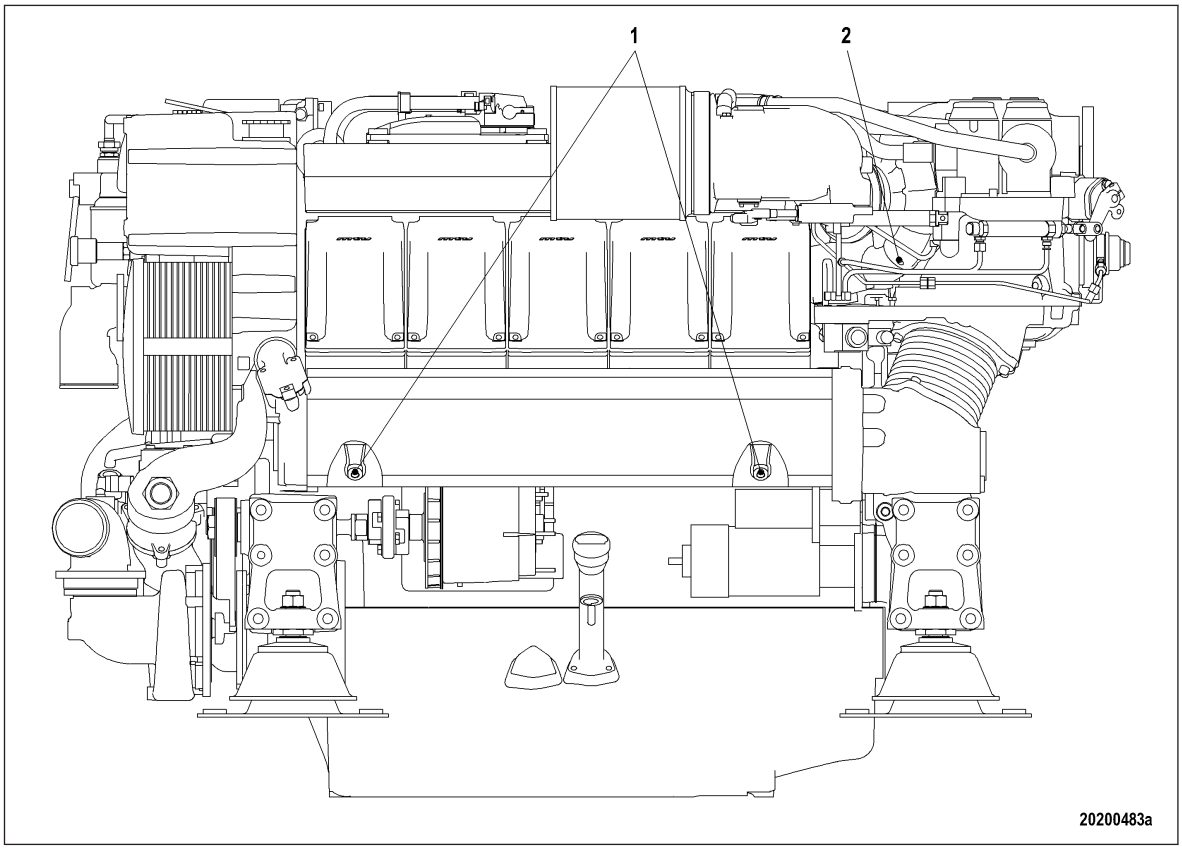
Free end (KGS)



1 Fuel filter vent screws
2 Engine coolant drain plug
3 Raw water pump filling plug
4 Measuring point, pressure before raw water pump
5 Raw water pump drain plug
6 Connection for oil extraction

TIM-ID: 0000006696 - 001

Left side

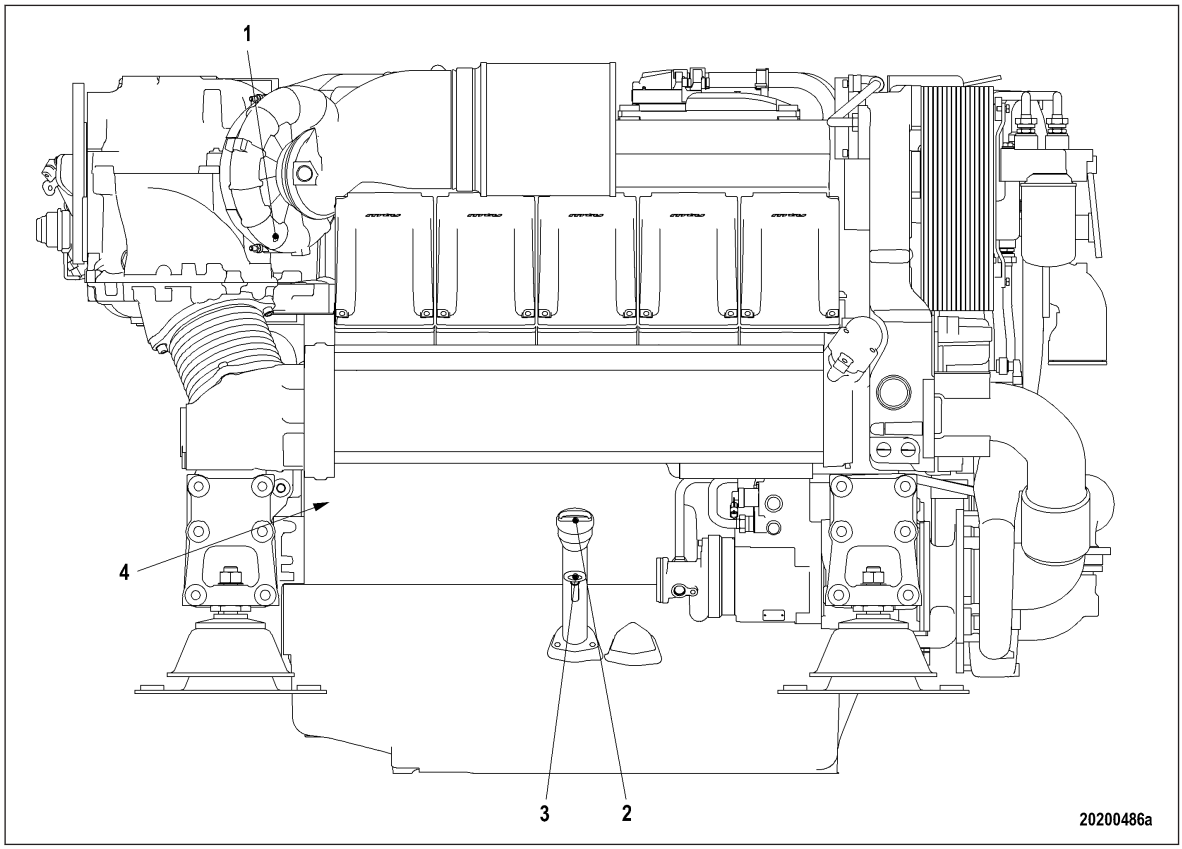


1 Engine coolant drain plug

2 Engine coolant drain plug (M14x1.5)

TIM-ID: 0000006696 - 001

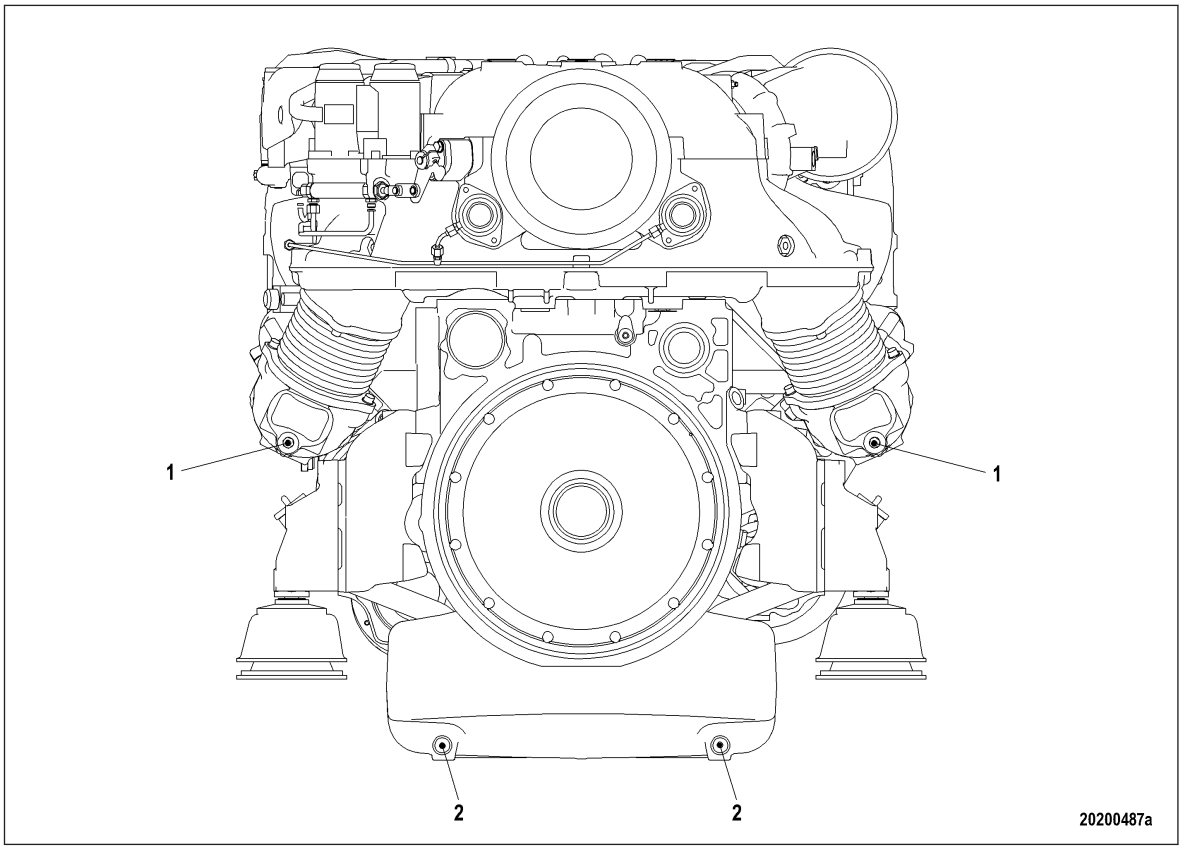
Right side



1 Engine coolant drain plug (M14x1.5)
2 Oil filler neck (connection left or right engine side optional)
3 Oil dipstick (connection left or right engine side optional)
4 Leak-off-fuel tank

TIM-ID: 0000006696 - 001

Driving end (KS)



1 Engine coolant drain plug

2 Connection for oil extraction

TIM-ID: 0000006696 - 001

7.15.2 Engine coolant – Level check

Preconditions

☑ Engine is stopped and starting disabled.

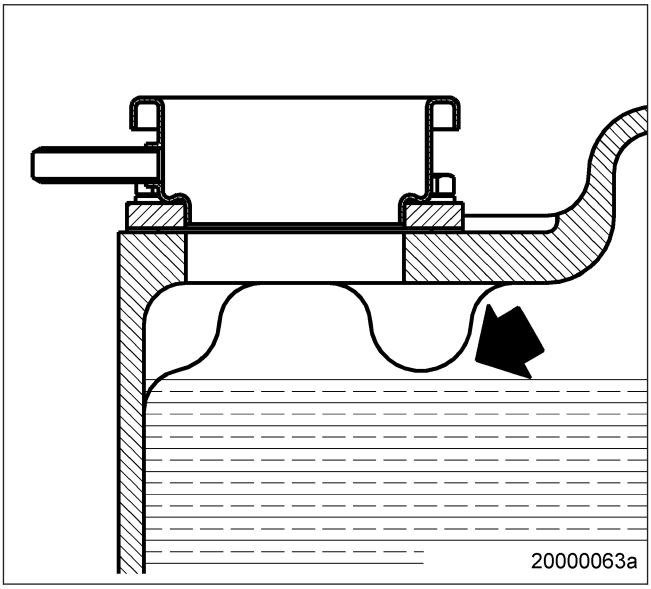
☑ MTU Fluids and Lubricants Specification (A001061/..) is available.

WARNING

Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Coolant-level check at filler neck:

1. Turn breather valve on coolant expansion tank (→ Page 26) counterclockwise until first stop and allow pressure to escape.
2. Continue to turn breather valve counter-clockwise and remove.
3. Check coolant level (coolant must be visible at the lower edge of the cast-in eye).



Coolant-level check by means of level sensor:

1. Switch engine control system on and check display (coolant level is automatically monitored by the engine control system).
2. If required, top up with treated engine coolant (→ Page 113).

TIM-ID: 0000006765 - 001

7.15.3 Motorkühlmittel wechseln

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Motorkühlmittel		

Motorkühlmittel wechseln

1. Motorkühlmittel ablassen (→ Page 112).
2. Motorkühlmittel einfüllen (→ Page 113).

TIM-ID: 0000000036 - 028

7.15.4 Engine coolant – Draining

Preconditions

☑ Engine is stopped and starting disabled.

WARNING

Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Preparatory steps

1. Provide an appropriate container to collect the coolant or
2. switch on the extraction device.
3. Switch off preheating unit.

Engine coolant – Draining

1. Turn breather valve on coolant expansion tank (→ Page 104)counterclockwise to the first stop and release pressure.
2. Continue to turn breather valve counterclockwise and remove.
3. Draw off precipitated corrosion inhibitor oil from the expansion tank through filler neck.
4. Open drain valves or drain plugs (→ Page 104) and drain or pump off coolant.
5. Close all open drain points.
6. Set breather valve onto filler neck and close it.

TIM-ID: 0000006746 - 001

7.15.5 Engine coolant – Filling

Preconditions

☑ Engine is stopped and starting disabled.

☑ MTU Fluids and Lubricants Specifications (A001061/..) are available.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Engine coolant		

WARNING

Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

CAUTION

Cold coolant in hot engine can cause thermal stress.
Formation of cracks in components!
- Fill / top up coolant only into cold engine.

Filling engine coolant

1. (→ Page 26)Turn breather valve of coolant expansion tank counterclockwise until the first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Pour coolant into engine until coolant level reaches lower edge of cast-in eye of filler neck.
4. Check proper condition of breather valve and clean sealing faces.
5. Place breather valve on filler neck and close.
6. Start the engine and operate it at idle speed for some minutes.
7. Check coolant level (→ Page 110).

TIM-ID: 0000006728 - 002

7.15.6 HT coolant pump — Relief bore check

DANGER

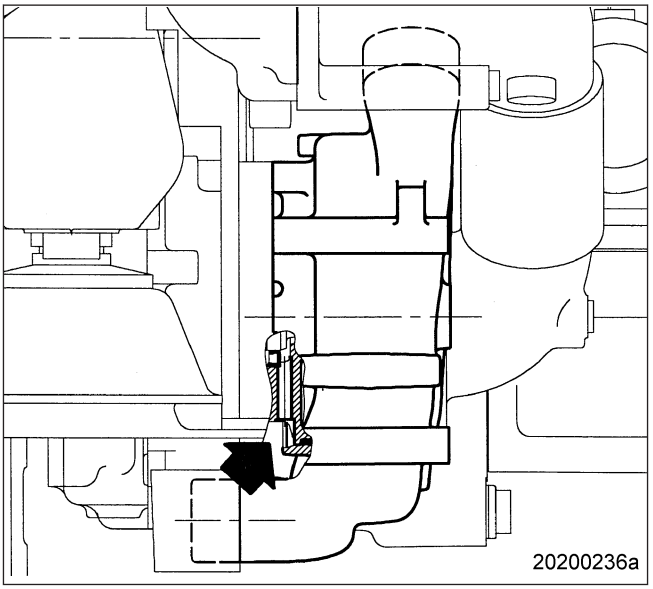
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

HT coolant pump — Relief bore check

1. Check relief bore for oil and coolant discharge.
2. Stop engine (→ Operating instructions electronic system) and disable engine start.
3. Clean the relief bore with a wire if it is dirty.
   - Permissible engine coolant discharge: up to 10 drops per hour;
   - Permissible oil discharge: up to 5 drops per hour.
4. If discharge exceeds the specified limits, contact Service.



TIM-ID: 0000006803 - 002

7.15.7 Engine coolant – Sample extraction and analysis

Preconditions

☑ Engine is stopped and starting disabled.

☑ MTU Fluids and Lubricants Specification (A001061/..) is available.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
MTU test kit	5605892099/00	1

WARNING

Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Engine coolant – Sample extraction and analysis

1. Turn breather valve on coolant expansion tank (→ Page 104)counterclockwise until first stop and allow pressure to escape.
2. Continue to turn breather valve counterclockwise and remove.
3. Draw off precipitated corrosion inhibitor oil from expansion tank and dispose of oil.
4. Draw off approx. 1 liter coolant and drain into a clean container.
5. Using the equipment and chemicals from the MTU test kit, examine coolant for:
   - antifreeze concentration;
   - corrosion inhibitor concentration;
   - pH value.
6. Fit breather valve and close it.
7. Change engine coolant according to the coolant operating times specified in the (→ MTU Fluids and Lubricants Specifications A001061/..)(→ Page 112).

TIM-ID: 0000006774 - 001

7.15.8 Coolant filter – Replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

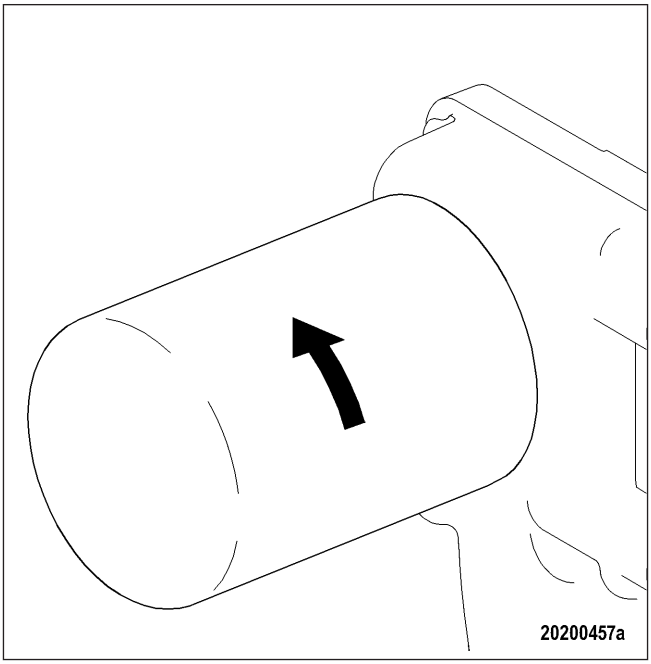
Designation / Use	Part No.	Qty.
Oil filter wrench	F30379104	1
Coolant filter	(→ Spare Parts Catalog)	

WARNING

Coolant is hot and under pressure.
Risk of injury and scalding!
- Let the engine cool down.
- Wear protective clothing, gloves, and goggles / safety mask.

Coolant filter – Replacement

1. Turn breather valve of coolant expansion tank counterclockwise (→ Page 26) to the first stop and allow pressure to escape.
2. Continue to turn breather valve counter-clockwise and remove.
3. Remove coolant filter using the oil filter wrench.
4. Clean the sealing face on the adapter.
5. Coat sealing ring of the new coolant filter with engine oil.
6. Install and tighten coolant filter by hand.
7. Close breather valve.
8. Check coolant level (→ Page 110).



TIM-ID: 0000006921 - 004

7.16 Raw Water Pump with Connections

7.16.1 Raw water pump – Relief bore check

DANGER

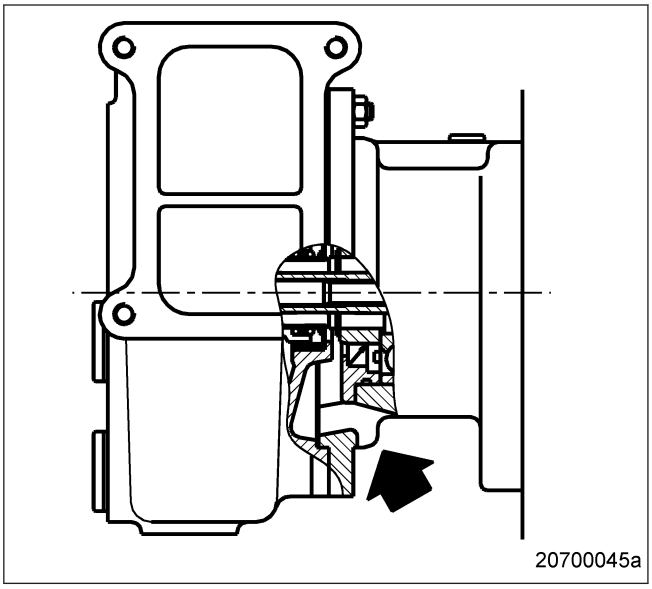
Unguarded rotating and moving engine components.
Risk of serious injury – danger to life!
- Take special care when working on a running engine.

WARNING

Engine noise above 85 dB (A).
Risk of damage to hearing!
- Wear ear protectors.

Raw water pump – Relief bore check

1. Check relief bore for oil and coolant discharge.
2. Stop engine (→ Page 50) and disable engine start.
3. Clean the relief bore with a wire if it is dirty.
   - Permissible coolant discharge: up to 10 drops per hour;
   - Permissible oil discharge: up to 5 drops per hour.
4. If discharge exceeds the specified limits, contact Service.



TIM-ID: 0000007284 - 001

7.17 Belt Drive

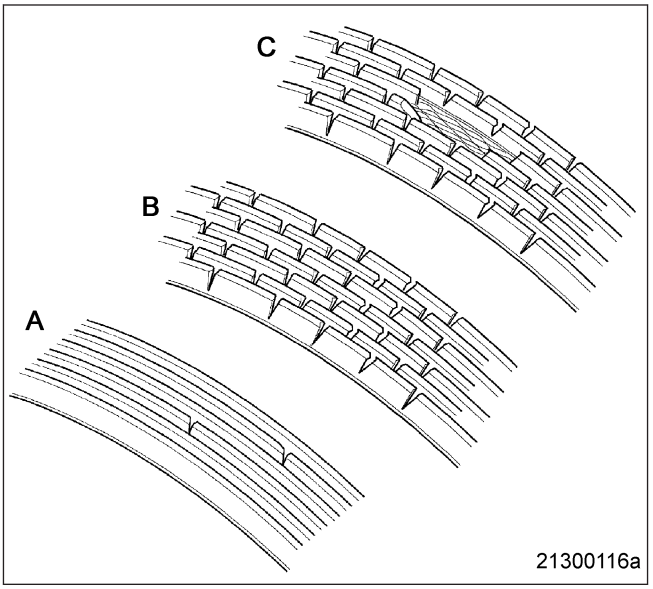
7.17.1 Drive belt – Condition check

Preconditions

☑ Engine is stopped and starting disabled.

☑ Guard is removed.

Drive belt – Condition check



Item	Findings	Action
Drive belt A	Singular cracks	None
Drive belt	Belt is oily, shows signs of overheating	Replace(→ Page 119)
Drive belt B	Cracks on entire circumference	
Drive belt C	Chunking	

TIM-ID: 0000000920 - 009

7.18 Battery-Charging Generator

7.18.1 Battery-charging generator drive – Drive belt replacement

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Mandrel	8205892861/08	1

Preparatory steps

1. Remove safety equipment (if fitted).
2. Remove screws of protective cover (engine free end).
3. Remove protective cover.

Drive belt – Replacement

1. Hold adjusting lever at square.
2. Rotate adjusting lever until drive belt is released.
3. Use mandrel to lock adjusting lever in position.
4. Remove drive belt.
5. Check cleanness of belt pulleys.
6. Fit new drive belt.
7. Remove mandrel.

Final steps

1. Install protective cover.
2. Install screws of protective cover.
3. Install safety equipment (if fitted).
4. Check function of safety equipment (if fitted).

TIM-ID: 0000007424 - 003

7.19 Fuel Supply System

7.19.1 Water drain valve – Check

Checking water drain valve

1. Open water drain valve.
2. Check water outlet for obstructions.
3. Close water drain valve.

TIM-ID: 0000007733 - 006

7.19.2 Differential pressure gauge – Check

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Checking differential pressure gauge

1. Switch on fuel treatment system (→ Page 48).
2. Set the alarm points at the differential pressure gauge to zero.

Result: Alarm is initiated with preset delay.

3. Reset the alarm points at the differential pressure gauge to the specified values.

TIM-ID: 0000007737 - 005

7.19.3 Water level probe (3-in-1 rod electrode) – Check

Preconditions

☑ System is put out of service and emptied.

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Water level probe (3-in-1 rod electrode) – Check

1. Disconnect plug from water level probe.
2. Unscrew water level probe.
3. Disconnect plug from water level probe.
4. Immerse water level probe into a tank filled with water until water level reaches the thread.

Result: Water drain valve opens.

5. Leave water level probe in tank.

Result: Alarm must be triggered with the preset delay.

6. Disconnect plug from water level probe.
7. Remove water level probe from tank.
8. Screw in water level probe.
9. Connect plug for water level probe.
10. Put the fuel treatment system into operation.

TIM-ID: 0000007739 - 006

7.19.4 Pump capacity – Check

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

Pump capacity – Check

1. Install suitable pressure gauge in the intake connection of the pump.
2. Check pump pressure.
   a) Switch on fuel treatment system (→ Page 48).

Note: The pressure limiting valve at the pump might respond and open. Audible noise is caused by overflowing fuel and can be disregarded.

   b) Close ball valve at the outlet of the fuel treatment system.
   c) Check pressure at the pressure gauge in the inlet to the fuel treatment system and note down.
3. Checking pump pressure with reduced suction
   a) Reduce suction pressure of pump to -0.8 bar with the shut-off valve at the pump intake side.
   b) Check pressure at the pressure gauge in the inlet to the fuel treatment system and note down.
   c) Open ball valve at inlet and outlet of fuel treatment system.
4. Calculate wear limit.

Example:	
Measured value (normal condition).	3 bar
Measured value (reduced suction condition).	2.6 bar
If the measured value (reduced suction condition) is 10% lower than the measured value (normal condition), the wear limit is reached. Repair pump (contact Service).	

TIM-ID: 0000028612 - 001

7.19.5 Coalescer filter element – Replacement

Preconditions

☑ System is switched off and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Torque wrench, 6-50 Nm	F30027336	1
Ratchet adapter	F30027339	1
Diesel fuel		
Engine oil		
Coalescer filter element	(→ Spare Parts Catalog)	
Gasket	(→ Spare Parts Catalog)	

WARNING

Fuels are combustible.
Risk of fire and explosion!
- Avoid open flames, electrical sparks and ignition sources.
- Do not smoke.

CAUTION

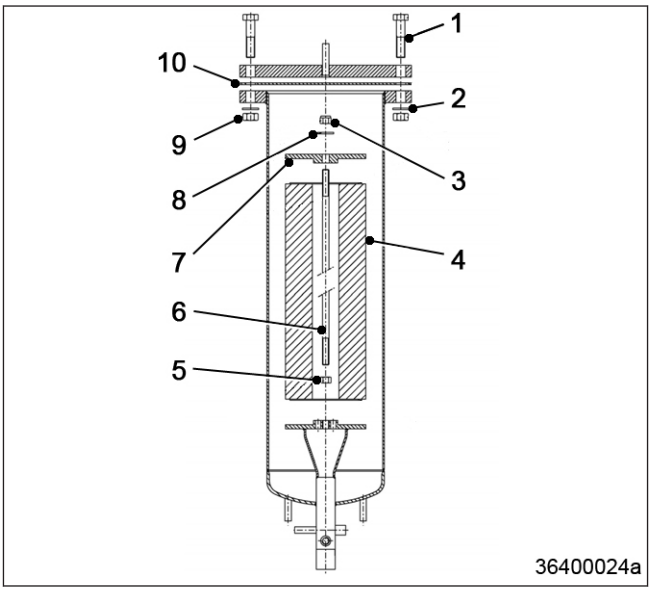
Contamination of components.
Damage to component!
- Observe manufacturer's instructions.
- Check components for special cleanness.

CAUTION

Incorrect installation of components and lines.
Damage to component!
- Ensure that components/lines are installed so that they are never under tension or strain.
- Ensure correct installation position of components.

Replacing coalescer filter element

1. Close ball valve at the inlet and outlet of the fuel treatment system.
2. Open drain valve.
3. Drain fuel.
4. Close drain valve.
5. Remove nut (9) with washer (2).
6. Remove screws (1).
7. Remove cover with gasket (10).
8. Remove nut (3), washer (8) and end plate (7).
9. Remove coalescer filter element (4).
10. Catch fuel as it runs out.
11. Clean housing with a non-linting cloth, rinse with fuel if required.
12. Check housing for corrosion.
13. Clean housing sealing surfaces.
14. Install coalescer filter element.
15. Install end plate (7), washer (8) and nut (3).



TIM-ID: 0000007735 - 006

16. Tighten nut (3) to specified tightening torque using a torque wrench.

Name	Size	Type	Lubricant	Value/Standard
Nut	M16	Tightening torque	(Engine oil)	30 Nm +3 Nm

17. Fit gasket (10).
18. Install cover.
19. Install screw (1), washer (2) and nut (9).
20. Tighten nut (9).
21. Open ball valve at the inlet and outlet of the fuel treatment system.

Result: The fuel treatment system is ready for operation.

TIM-ID: 0000007735 - 006

7.20 Wiring (General) for Engine/Gearbox/Unit

7.20.1 Engine wiring – Check

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol	X00058037	1

Engine wiring – Check

1. Check securing screws of cable clamps on engine and tighten loose threaded connections.
2. Ensure that cables are fixed in their clamps and cannot swing freely.
3. Check that cable ties are firm, tighten loose cable ties.
4. Replace faulty cable ties.
5. Visually inspect the following electrical line components for damage:
   - connector housings;
   - contacts;
   - sockets;
   - cables and terminals;
   - plug-in contacts.
6. (→ Contact Service) if cable conductors are damaged.

Note: Close male connectors that are not plugged in with the protective cap supplied.

7. Clean dirty connector housings, sockets and contacts with isopropyl alcohol.
8. Ensure that all sensor connectors are securely engaged.

TIM-ID: 0000000029 - 018

7.21 Accessories for (Electronic) Engine Governor / Control System

7.21.1 Engine governor and connectors – Cleaning

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol	X00058037	1

Note: Always use test connectors to enter the connectors. Never use test leads for this purpose.Otherwise the contacts could be bent.

Engine governor and connectors – Cleaning

1. Remove coarse dirt from housing surface with isopropyl alcohol.
2. Remove dirt from connector and cable surfaces with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.

Cleaning severely contaminated connectors on the engine governor

Note: Seal unused connectors with the supplied protective cap.

1. Release the latch and pull off connectors.
2. Clean connector housings, connector socket housings and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and lock them.

TIM-ID: 0000000047 - 009

7.21.2 Engine governor – Checking plug-in connections

Preconditions

☑ Engine is stopped and starting disabled.

Note: Always use test connectors to enter the connectors. Never use test leads for this purpose.Otherwise the contacts could be bent.

Checking plug-in connections on engine governor

1. Check all plug-in connections for secure seating.
2. Latch connectors if loose.

TIM-ID: 000000048 - 005

7.21.3 EMU – Checking plug-in connections

Preconditions

☑ Engine is stopped and starting disabled.

EMU – checking plug-in connections

1. Verify that all plug-in connections are securely seated.
2. Secure loose connectors and latch.

TIM-ID: 0000008395 - 001

7.21.4 Engine governor – Carry out self-test

DANGER

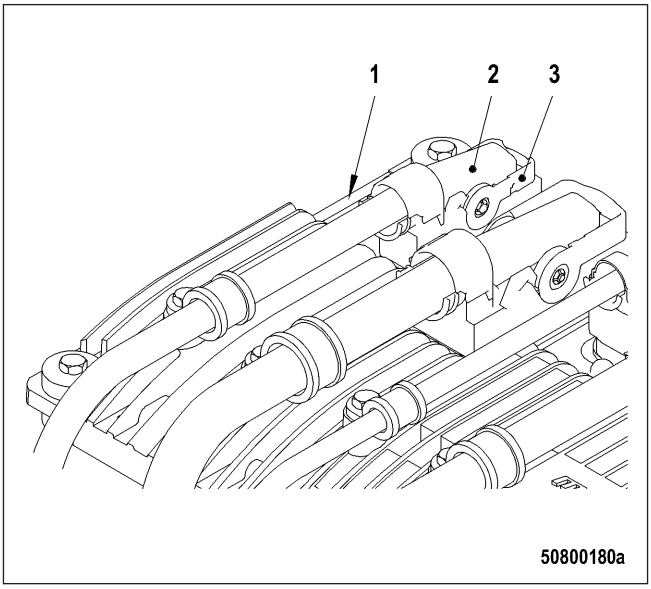
Electrical voltage.
Risk of serious injury - danger to life!
- Make certain that the power supply to the engine is switched off before starting to work. Ensure that the power supply cannot be switched on unintentionally!

Carrying out self-test

1. Switch off power supply to system.
2. Remove connectors X1, X2 and X4 from the engine governor.
   a) Release lock (3) of connectors (2).
   b) Unplug connector (2).
3. Switch on power supply

Result:
- The engine governor is operable if the diagnostic lamp (1) changes to continuous illumination within 30 seconds after power has been switched on.
- If the diagnostic lamp (1) flashes after 30 seconds, replace engine governor and (→ contact Service).
- Check the power supply if the diagnostic lamp remains dark.

4. Switch off power supply.
5. Refit connectors X1, X2 and X4 on engine governor.
   a) Plug in connector (2).
   b) Lock connectors.



TIM-ID: 0000008482 - 002

7.21.5 EMU and connectors – Cleaning

Preconditions

☑ Engine is stopped and starting disabled.

Special tools, Material, Spare parts

Designation / Use	Part No.	Qty.
Isopropyl alcohol		

EMU and connectors – Cleaning

1. Remove coarse dirt from housing surface using a cloth moistened with isopropyl alcohol.
2. Remove dirt from connector and cable surfaces with isopropyl alcohol.
3. Check legibility of cable labels. Clean or replace illegible labels.

Cleaning severely contaminated EMU connectors

1. Release latches of connectors and withdraw connectors.
2. Clean connector housings, connector socket housings and all contacts with isopropyl alcohol.
3. When connectors, sockets and all contacts are dry: Fit connectors and secure latches.

TIM-ID: 0000008392 - 001

7.21.6 ECU 7 engine governor – Removal and installation

Preconditions

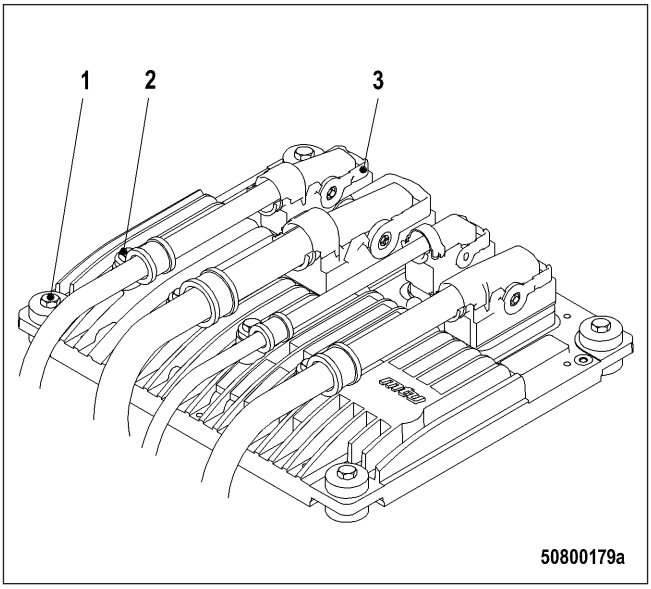
☑ Engine is stopped and starting disabled.

CAUTION

Wrong engine governor installed.
Engine damage!
- When reassembling an engine, make sure that the governor with the data record for the given engine is installed.

Removing engine governor from engine

1. Note or mark assignment of cables and connectors.
2. Remove all screws (2).
3. Undo latches (3) of the connectors.
4. Remove all connectors.
5. Remove screws (1).
6. Take off engine governor.



Installing engine governor on engine

1. Install in reverse order. In doing so, ensure correct assignment of connectors and sockets.
2. Check rubber mount before installation.

Result: If the rubber mount is porous or defective, replace it.

TIM-ID: 0000000049 - 005

7.21.7 Engine monitoring unit – Removal and installation

Preconditions

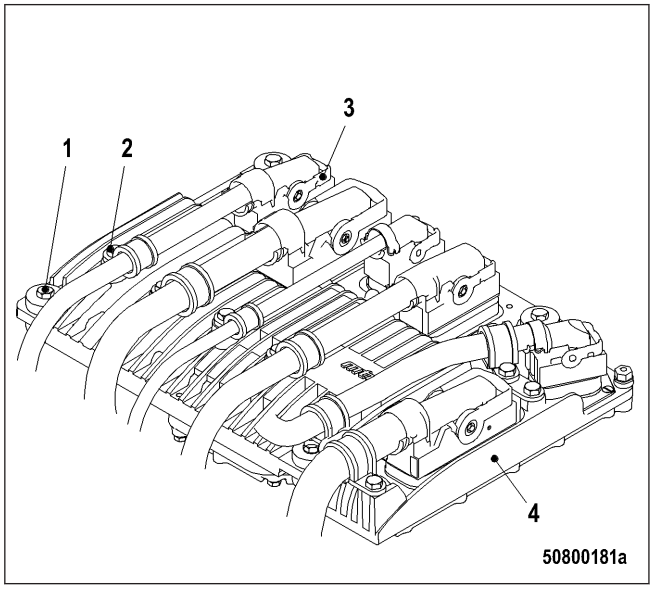
☑ Engine is stopped and starting disabled.

CAUTION

Wrong engine governor installed.
Engine damage!
- When reassembling an engine, make sure that the governor with the data record for the given engine is installed.

Removing engine governor with engine monitoring unit from engine

1. Note or mark assignment of cables and plugs.
2. Remove all screws (2).
3. Release lock (3) of connectors..
4. Remove all connectors.
5. Remove screws (1).
6. Remove engine governor (1) with engine monitoring unit (4).



Removing engine monitoring unit

1. Unscrew screws on base of EMU (4).
2. Remove EMU (4) with engine governor (1).

Installing engine monitoring unit

1. Place EMU (4) in position at engine governor (1).
2. Screw in and tighten screws on base of EMU (4).

Installing engine governor with engine monitoring unit on engine

1. Install in reverse order. Ensure correct assignment of plugs and sockets.
2. Check resilient mount before installing.

Result: If resilient mount is porous or defective then replace it.

TIM-ID: 0000008493 - 002

8 Appendix A

8.1 Abbreviations

Abbreviation	Meaning	Explanation
AC	Alternating Current	
ADEC	Advanced Diesel Engine Controller	Engine management system
AL	Alarm	
ANSI	American National Standards Institute	Association of American standardization organizations
ATL	Abgasturbolader	Exhaust turbocharger (ETC)
BDM	Backup Data Module	
BR	Baureihe	Series
BV	Betriebsstoffvorschrift	MTU Publication No. A01061/..
CAN	Controller Area Network	Data bus system, bus standard
CDC	Calibration Drift Compensation	Setting the drift correction with DiaSys in the engine control system
CRC	Cyclic Redundancy Control	Check sum procedure to detect data transmission faults
DC	Direct Current	
DIFF	Difference	
DIN	Deutsches Institut für Normung e. V.	At the same time identifier of German standards (DIN = “Deutsche Industrie-Norm”)
DL	Default Lost	Alarm: Default CAN bus failure
DPF	Diesel particulate filter	
ECU	Engine Control Unit	Engine governor
EGR	Exhaust Gas Recirculation	
ETK	Ersatzteilkatalog	Spare Parts Catalog (SPC)
FO	Frequency output	
GND	Ground	
HP	High pressure	
HI	High	Alarm: Measured value exceeds 1st maximum limit
HIHI	High High	Alarm: Measured value exceeds 2nd maximum limit
HT	High Temperature	
ID	Identification number	
ISO	International Organization for Standardization	International umbrella organization for all national standardization institutes
ITS	Integrated Test System	
KGS	Kraftgegenseite	Engine free end in accordance with DIN ISO 1204

TIM-ID: 0000009959 - 005

Abbreviation	Meaning	Explanation
KS	Kraftseite	Engine driving end in accordance with DIN ISO 1204
LED	Light Emitting Diode	
LO	Low	Alarm: Measured value lower than 1st minimum limit
LOLO	Low Low	Alarm: Measured value lower than 2nd minimum limit
MTU	Motoren- und Turbinenunion	
MV	Magnetventil	Solenoid valve
OEM	Original Equipment Manufacturer	
OT	Oberer Totpunkt	Top dead center (TDC)
PAU	Power Automation Unit	Module for monitoring, control and plant-related system integration of peripheral components
PDU	Process Data Unit	
POM	Power Output Module	Module to control starter and battery-charging generator
PU	Projektierungsumgebung	Project planning environment
P-xyz	Pressure-xyz	Pressure measuring point xyz, xyz specifies the measuring point designation
SAE	Society of Automotive Engineers	U.S. standardization organization
SAM	Service and Application Module	Module for servicing and diagnostics
SD	Sensor Defect	Alarm: Sensor failure
SS	Safety System	Safety system alarm
TBO	Time Between Overhaul	
T-xyz	Temperature-xyz	Temperature measuring point, xyz specifies the measuring point designation
U	Symbol for electric voltage	
UIC	Union Internationale des Chemins de Fer	International railway association
UT	Unterer Totpunkt	Bottom dead center (BDC)
WZK	Werkzeugkatalog	Tool Catalog (TC)

TIM-ID: 0000009959 - 005

8.2 MTU contacts/service partners

Service

Our worldwide sales network with its subsidiaries, sales offices, representatives and customer service centers ensures fast and direct support on site and the high availability of our products.

Local support

Experienced and qualified specialists place their knowledge and expertise at your disposal.

For locally available support, go to the MTU internet site: http://www.mtu-online.com

24h hotline

With our 24h hotline and the outstanding flexibility of our service staff, we are always ready to assist you - either during operation, for preventive maintenance, corrective work in case of malfunction or changed operating conditions, or for spare parts supply.

Your contact at Headquarters:Service-support@mtu-online.com

Spare parts service

Fast, simple and correct identification of spare parts for your drive system or vehicle fleet. The right spare part at the right time at the right place.

With this aim in mind, we can call on a globally networked spares logistics system

- a central depot at Headquarters, as well as decentralized depots among our subsidiaries, representatives and contractual workshops.

Your contact at Headquarters:

E-mail: spare.parts@mtu-online.com

Phone: +49 7541 908555

Fax: +49 7541 908121

TIM-ID: 0000000873 - 012

9 Appendix B

9.1 Special Tools

Alignment device	
Part No.:	F6790507
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

Angular screw driver	
Part No.:	F30002816
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Bandschlüssel	
Part No.:	F30379104
Qty.: Used in:	1 7.14.2 Ölzentrifuge reinigen und Einlegemanschette ersetzen (→ Page 101)

Barring tool	
Part No.:	F6783914
Qty.: Used in:	1 7.2.1 Engine – Barring manually (→ Page 67)
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Box wrench adapter	
Part No.:	F30451199
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

Centering device	
Part No.:	F6783025
Qty.: Used in:	1 7.5.2 Cylinder-head cover – Removal and installation (→ Page 79)

Double box wrench	
Part No.:	F30002800
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Double box wrench	
Part No.:	F30011450
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

DCL-ID: 0000010704 - 003

Drehmomentschlüssel, 6-50 Nm	
Part No.:	F30027336
Qty.: Used in:	1 7.4.2 Kurbelgehäuseentlüftung – Ölabscheidereinsatz ersetzen, Membrane prüfen und ersetzen (→ Page 74)

Einsteckknarre	
Part No.:	F30027340
Qty.: Used in:	1 7.4.2 Kurbelgehäuseentlüftung – Ölabscheidereinsatz ersetzen, Membrane prüfen und ersetzen (→ Page 74)

Feeler gauge	
Part No.:	Y4345893
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Mandrel	
Part No.:	8205892861/08
Qty.: Used in:	1 7.18.1 Battery-charging generator drive – Drive belt replacement (→ Page 119)

MTU test kit	
Part No.:	5605892099/00
Qty.: Used in:	1 7.15.7 Engine coolant – Sample extraction and analysis (→ Page 115)

Oil filter wrench	
Part No.:	F30379104
Qty.: Used in:	1 7.8.1 Fuel filter – Replacement (→ Page 84)
Qty.: Used in:	1 7.14.1 Engine oil filter – Replacement (→ Page 99)
Qty.: Used in:	1 7.15.8 Coolant filter – Replacement (→ Page 116)

Open end wrench bit	
Part No.:	F30025897
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

Puller	
Part No.:	F6790629
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

DCL-ID: 000001704 - 003

Ratchet	
Part No.:	F30006212
Qty.: Used in:	1 7.2.1 Engine – Barring manually (→ Page 67)
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Ratchet adapter	
Part No.:	F30027339
Qty.: Used in:	1 7.19.5 Coalescer filter element – Replacement (→ Page 124)

Rigid endoscope	
Part No.:	Y20097353
Qty.: Used in:	1 7.3.1 Cylinder liner – Endoscopic examination (→ Page 69)

Socket wrench	
Part No.:	F30030450
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Socket wrench	
Part No.:	0005896803/00
Qty.: Used in:	1 7.6.2 Injector – Removal and installation (→ Page 81)

Steam jet cleaner	
Part No.:	-
Qty.: Used in:	1 4.13 Plant – Cleaning (→ Page 54)

Torque wrench, 10-60 Nm	
Part No.:	F30510423
Qty.: Used in:	1 7.5.1 Valve clearance – Check and adjustment (→ Page 76)

Torque wrench, 6-50 Nm	
Part No.:	F30027336
Qty.: Used in:	1 7.19.5 Coalescer filter element – Replacement (→ Page 124)

DCL-ID: 0000010704 - 003

9.2 Index

12V 2000 M94 ENGINE DATA 33, 36

A

Abbreviations 134
After stopping the engine 52
Air filter
– Removal and installation 94
Auxiliary materials 16

B

Battery-charging generator drive
– Drive belt
  – Replacement 119

C

Checks
– Prior to start-up 44
Coalescer
– filter element
  – Replacement 124
Coalescer filter element
– Replacement 124
Connectors
– Cleaning 127
Contact persons 136
Contamination indicator
– Signal ring position check 95
Coolant
– Filter
  – Replacement 116
Coolant filter
– Replacement 116
Crankcase breather – Cleaning oil pre-separator element 73
Cylinder
– Designations 19
Cylinder liner
– Endoscopic examination 69
– Instructions and comments on endoscopic and visual examination 71
Cylinder-head cover – Removal and installation 79

D

Differential pressure gauge
– Check 121
Drain and venting points 104
Drive belt
– Condition check 118

E

ECU 7 engine governor
– Removal and installation 132
Emergency stop 51
EMU and connectors – Cleaning 131
EMU – Checking plug-in connections 129
Engine
– Barring manually 67
– Main dimensions 40
– Overview 26
– Wiring check 126
Engine - barring with starting equipment 68
Engine coolant
– Filling 113
Engine coolant – Draining 112
Engine coolant – Level check 110
Engine coolant – Sample extraction and analysis 115
Engine governor
– Carry out self-test 130
– Checking plug-in connections 128
– Cleaning 127
Engine monitoring unit
– Removal and installation 133
Engine oil
– Change 98
Engine oil filter
– Replacement 99
Engine oil level
– Check 97
Engine side
– Designations 19
Engine wiring
– Check 126
Environmental protection 16

F

Filter
– Coolant
  – Replacement 116
Fire prevention 16
Firing order 39
Fluids and lubricants 16
Fuel
– Prefilter
  – Differential pressure gauge - Check and adjustment 86
  – Draining 87
  – Filter element replacement 90
– Treatment system
  – Troubleshooting 56
– treatment system
  – Shutdown 53
  – Switching on 48
Fuel filter
– Replacement 84
Fuel prefilter
– Differential pressure gauge
  – Check and adjustment 86
– Draining 87
– Filter element
  – Replacement 90
Fuel system – Venting 83

DCL-ID: 000001070 4 - 003

Fuel treatment system
– Putting into operation 45
– Shutdown 53
– Switching on 48

G

General conditions 7

H

HT coolant pump
– Relief bore check 114

I

Injector
– Removal and installation 81
Injector – Replacement 80
Installation locations for SOLAS shielding 62
Intercooler – Checking condensate drain line for coolant discharge and obstruction 92

K

Kraftstoff
– Vorfilter
  – spülen 88
Kraftstoffvorfilter
– spülen 88
Kurbelgehäuseentlüftung
– Membrane ersetzen 74
– Membrane prüfen 74
– Ölabscheidereinsatz ersetzen 74

L

Luftfilter
– ersetzen 93

M

Maintenance work
– Safety regulations 13
Motorkühlmittel
– wechseln 111
MTU contact persons 136

O

Ölabscheidereinsatz
– ersetzen 74
Ölzentrifuge
– Einlegemanschette ersetzen 101
– reinigen 101
Operation
– Safety regulations 12
Operational checks 47

P

Personnel and organizational requirements 8
Plant
– Cleaning 54
Product description 20
Pump capacity
– Check 123
Putting engine into operation
– Preparation after extended out-of-service periods (>3 months) 41
Putting into operation
– Fuel treatment system 45
– Preparation after scheduled out-of-service period 42

R

Raw water pump – Relief bore check 117
Repair work
– Safety regulations 13

S

Safety instructions 18
Safety regulations 12, 13
Sensors, actuators and injectors
– Overview 28
Service partners 136
SOLAS shielding as per MTN 5233 – Installation 60
SOLAS- Abschirmung
– anbringen 61
Starter
– Condition check 96
Starting the engine 49
Startup
– Safety regulations 12
Stopping the engine 50

T

Tasks
– After extended out-of-service periods 43
Tasks after extended out-of-service periods (>3 weeks) 43
Transport 9
Troubleshooting 57
– Fuel treatment system 56

V

Valve clearance – Check and adjustment 76

W

Water drain valve
– Check 120
Water level probe (3-in-1 rod electrode)
– Check 122
Wiring - engine
– Check 126

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